Section: Ophthalmology

Original Research Article

A CLINICAL EVALUATION OF NEODYMIUM YAG LASER CAPSULOTOMY: ENERGY LEVELS FOR DIFFERENT GRADES OF PCO AND TREATMENT OUTCOMES

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ABSTRACT

Background: Neodymium: Yattrium-Aluminum-Garnet (Nd: YAG) laser capsulotomy is a safe technique, performed for making an opening in the opacified posterior capsules. The denser the PCO there is tendency of more energy to be used, Nd: YAG capsulotomy is associated with significant anterior and posterior segment complications. This study is on impact of Nd: YAG laser energy on the rate of complications and a causal relation. Objectives: To find out association between the grade and type of PCO with energy used and its outcome.

Materials and Methods: A Q-Switched Nd: YAG laser system with wavelength of 1064 nm and pulse length of <4 ns (2-3 ns) was employed after full dilatation of pupil capsulotomy of about 4 mm in size was created. Initial setting of 1mJ and subsequent increase of 0.5 mJ as necessary used to make an opening in the posterior capsule and the number of pulses used to create capsulotomy and summated total laser energy was noted in each case. Patients were followed for 6 months each visit patients' visual acuity, refraction, fundoscopy and IOP were examined and analyzed.

Results: Out of 100 patients' maximum number are in membranous (54%) followed by fibrous (27%) and least is fibro-membranous (19%). Among membranous subtype a greater number of patients belong to Grade 2 PCO (48.1%). Whereas in patients with Fibrous subtype maximum patients presents with Grade 4PCO (59.3%). Maximum energy is required for grade 4 (46.6 mJ) and least is for grade 1(9.7) More energy is required for fibrous (39.2mJ) and least is for membranous (26.7mJ). The complications such as IOP spikes, uveitis, hyaloid face rupture, IOL pitting, CME are common with higher total laser energy levels.

Conclusion: Grade and Type of PCO significantly influenced laser energy levels required for capsulotomy, whereas Complications such as IOL pitting, uveitis, IOP elevation, hyaloid face rupture and CME was significantly more common when total laser energy was higher.

Key words: Posterior Capsular Opacity, Nd- YAG capsulotomy, Energy used for Capsulotomy.

INTRODUCTION

Posterior capsular opacification is a common late complication of cataract surgery as a result of proliferation of residual lens epithelial cells which causes fibrotic changes and wrinkling of the posterior capsule overall, 25% of patients undergoing extra-capsular cataract surgery develops visually significant PCO within 5 years of the operation.[2]

PCO present with gradual decrease in visual acuity after successful cataract surgery. Although various methods employed for prevention like capsular polishing, implanting IOL's with convex posterior surface, surface-modified lens, use of antimitotic etc., have not been shown to be very successful in long term follow up.[3]

Nd: YAG laser provides the advantage of cutting the posterior lens capsule, capsular membrane, strands and adhesions without surgical intervention, thereby avoiding and minimizing infection, wound leaks, and other complication of intraocular surgery. Thus Nd: YAG laser capsulotomy is noninvasive, effective and relatively safe technique.[4]

However, Nd:YAG capsulotomy is associated with significant anterior and posterior segment complications. The denser the PCO there is tendency of more energy to be used so we hypothesized that more energy used for more denser PCO. Some studies recommend that side effects are more pronounced when higher single pulse energy levels are used rather than higher total laser energy and proposed that the procedure should be performed at the lowest possible energy level in order to avoid IOL damage.[6]

This study mainly aims to find the optimal energy required for a particular density of PCO to minimize the complications and to maximize the visual outcome and also to analyze the effect of various forms of PCO capsulotomy openings on visual function after Nd: YAG capsulotomy.

Objectives of the Study

To find out association between the grade and type of PCO with energy used and its outcome.

MATERIALS AND METHODS

Inclusion Criteria: All patients presented with diminution of vision due to posterior capsular opacity

1. Evident posterior capsular thickening/opacification on examination with slit lamp.
2. Post-op cataract surgery, decrease in vision by at least 3 lines on Snellen's chart.
3. At least 3 months interval between cataract surgery and development of posterior capsular opacification.
4. PCO following complicated cataracts.
5. Pre-existing posterior capsular opacification (present before cataract surgery).

Exclusion Criteria: Following patients will be excluded from the study:

1. Patients < 5 years age.
2. Eyes with subluxated intraocular lens.
3. Includes severe coexisting ocular disease,

Glaucoma

Corneal opacity

Diabetic retinopathy

Age-related macular degeneration and other macular pathologies.

Retinal detachment.

4. Un-co-operative subjects. Eg: patients with mental retardation, neurological problems.
5. Aphakic eyes.

Methodology: Study was conducted over a period of 14 months (December 2017 to January 2019) and follow up for 6months (February 2019 to July 2019).

Study was conducted in about 100 PCO fulfilling the inclusion criteria after obtaining the informed consent from the participants are subjected to-

- A detailed clinical history includes date of cataract surgery, interval between cataract surgery and onset of defective vision, history of glaucoma, history of any systemic illnesses or surgery, history of any other ocular conditions.
- Detailed examination of both eyes along with general physical examination.
- Visual acuity testing with Snellen's chart.
- Examination of anterior segment of eye by slit lamp biomicroscopy.
- Measurement of intraocular pressure using applanation tonometer (Perkins).
- Examination of posterior segment of eye by ophthalmoscopy (direct and indirect) and +90 D biomicroscopy and grading of PCO done according to Sellman and Lindstrom grading system.[21]

Sellman and Lindstrom graded fibrosis and Elschnig pearl formation on a similar four-point scale into

1. No or slight PCO without reduced red reflex, also no pearls at all or pearls not to the IOL edge;
2. Mild PCO reducing the red reflex, Elschnig pearls to the IOL edge;
3. Moderate fibrosis or Elschnig pearls inside IOL edge but with a clear visual axis;
4. Sever fibrosis or Elschnig pearls covering visual axis and severely reducing red reflex.

After full dilatation of pupil, a Q-switched Nd: YAG laser system (YAG II plus, Appa swamy, India) with wavelength of 1064 nm and pulse length of <4 ns (2-3 ns) was employed for this study.

MANAGEMENT OF COMPLICATIONS:

Increased IOP may be treated with brimonidine, apraclonidine, topical beta-adrenergic antagonists, prostaglandin analogue, topical or systemic carbonic anhydrase inhibitor or hyperosmotic agents. Patient's medical history, allergies and current ocular therapy should be reviewed before determining the appropriate acute antiglaucoma therapy. Continue antiglaucoma therapy for at least 1 week to prevent a delayed pressure elevation. Measure IOP again about 1 week after laser surgery and sooner if indicated by a pressure increase or preexisting glaucomatous optic nerve damage or visual field loss.

Incidence of new CME is low following laser capsulotomy, although some patients may acquire CME at a later date. Risk of CME could be lowered

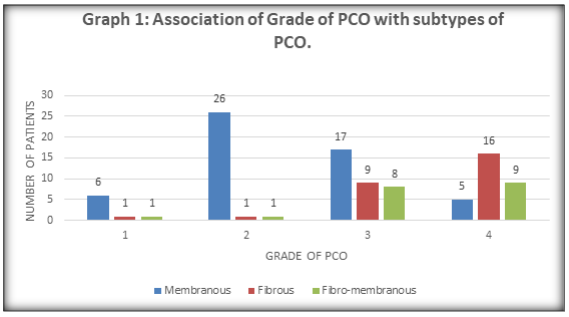
by a longer interval between extracapsular cataract extraction and laser capsulotomy, although other studies have not confirmed this. Treatment of CME following Nd: YAG laser posterior capsulotomy is NSAIDS – Topical or systemic indomethacin, Ketorolac tromethamine 0.5%, indomethacin 1%, and diclofenac 1%.

Corticosteroids – Topical, periocular, systemic, intravitreal injection or implant corticosteroids Carbonic anhydrase inhibitors (CAIs) –tab. Diamox Anti-VEGF agents – Pegaptanib, ranibizumab

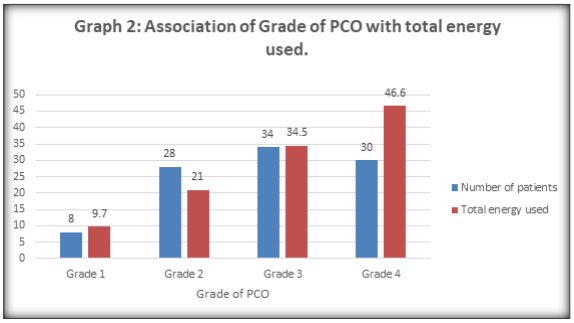
Proper selections of cases are important as **pitting of IOL** may occur in uncooperative patients. Nd: YAG laser capsulotomy should be done at least 3 months after cataract surgery to decrease the incidence of iritis. Iritis patients treated with topical Prednisolone, Homatropine eye drops and systemic NSAIDS.

RESULTS

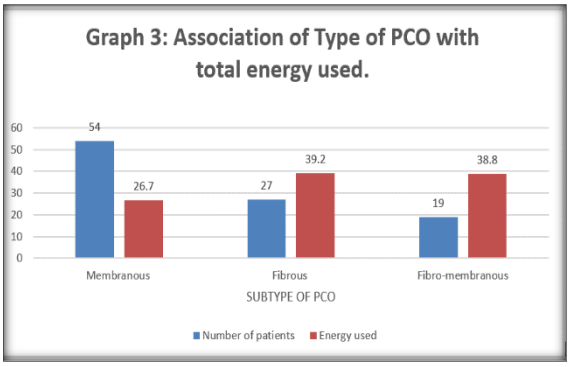
After a study of 18 months Dec2017- May 2019 the following observations were made, 100 patients were identified having posterior capsular opacity diagnosed by red reflex evaluation by slit lamp examination, direct and indirect retinoscopy. These Cases were divided according to age/sex wise and PCO was graded based on view of fundus details and Nd: YAG laser capsulotomy done for all the cases. Total energy used, Pre-laser and post-laser visual acuity recorded, compared and analyzed and post-laser complications of Nd: YAG laser were recorded, followed and treated.



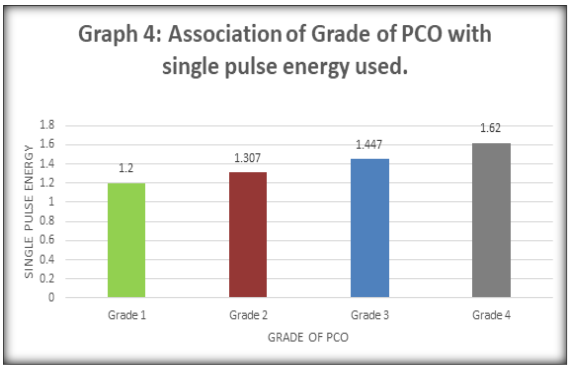
Graph 1: Showing a greater number of patients are membranous with lesser grade of PCO and less number of patients are fibrous and fibro membranous with higher grade of PCO



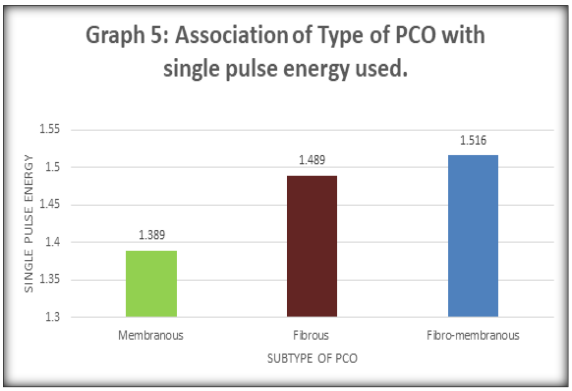
Graph 2: Showing higher the grade higher the energy used.



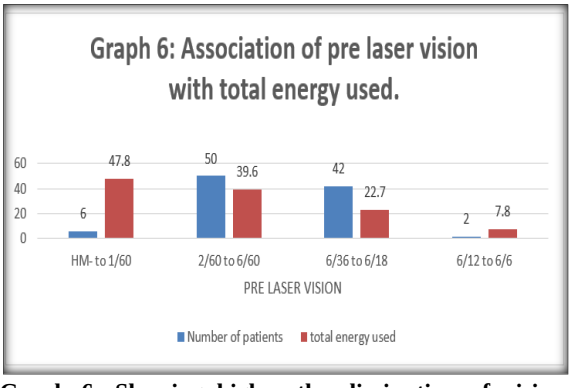
Graph 3: Showing fibrous and fibro-membranous requires higher energy compared to membranous subtype.



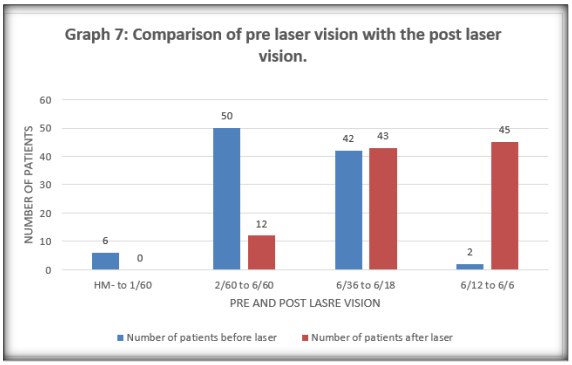
Graph 4: Showing higher the grade higher the single pulse energy required.



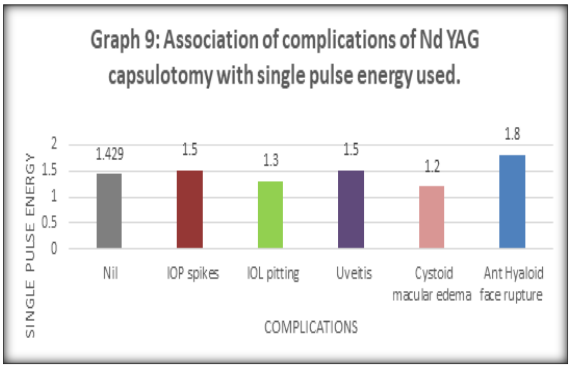
Graph 5: Showing fibro-membranous requires higher single energy compared to membranous



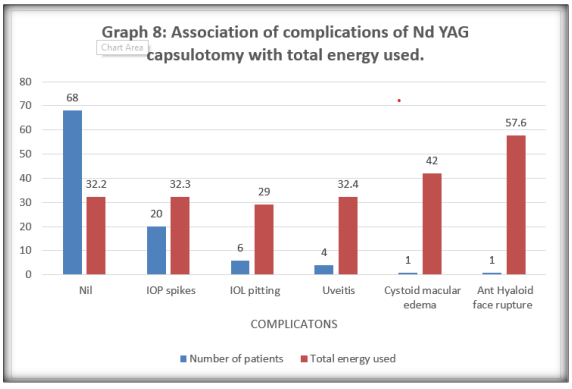
Graph 6: Showing higher the diminution of vision higher the energy required



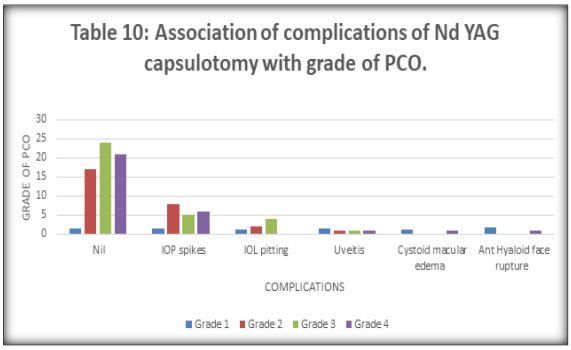
Graph 7: Showing pre laser patients more in 2/60 to 6/60 group and post laser more in 6/12 to 6/6 group



Graph 9: Showing rate of complications is more when higher the single pulse energy used



Graph 8: Showing higher the total energy used higher the rate of complications



Graph 10: Showing Grade 2 and Grade 3 PCO cases presents with higher rate of complications after Nd: YAG laser capsulotomy

Table 1: Association of Grade of PCO with subtypes of PCO

Type of PCO	Grade				Total
	1	2	3	4	
Membranous	6 11.1%	26 48.1%	17 31.5%	5 9.3%	54 100.0%
Fibrous	1 3.7%	1 3.7%	9 33.3%	16 59.3%	27 100.0%
Fibro-membranous	1 5.3%	1 5.3%	8 42.1%	9 47.4%	19 100.0%
Total	8 8.0%	28 28.0%	34 34.0%	30 30.0%	100 100.0%

Out of 100 patients' maximum number are in membranous (54%) followed by fibrous (27%) and least is fibro-membranous (19%).
Among membranous subtype a greater number of patients belong to Grade 2(48.1%). Whereas in patients with Fibrous subtype maximum patients presents with Grade 4(59.3%).
And which is statistically significant with p< 0.001.

Table 2: Association of Grade of PCO with total energy used

grade	N	Mean energy(mJ)	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
1	8	9.7	6.992760	12.507240
2	28	21.0	18.521980	23.563734
3	34	34.5	30.830898	38.169102
4	30	46.6	44.031246	49.248754
Total	100	32.3	29.557523	35.230477

Maximum number of patients presents with grade 3 and least by grade 1,
Maximum energy is required for grade 4 (46.6 mj) with 95% confidence interval of 44.03-49.2 and least is for grade 1(9.7) with confidence interval of (6.99- 12.5).
Which is statistically significant with p< 0.001.

Table 3: Association of Type of PCO with total energy used

Type of PCO	N	Mean energy(mJ)	95% Confidence Interval for Mean	
			Lower Bound	Upper bound
Membranous	54	26.7	23.073617	30.393050
Fibrous	27	39.2	34.107266	44.248289
Fibro-membranous	19	38.8	32.973883	44.710328
Total	100	32.9	29.557523	35.230477

Moreenergy is required for fibrous (39.2mJ) with 95% confidence interval of (34.1-44.2) and least is for membranous (26.7mJ) with confidence interval of (23.07- 30.39).
Which is statistically significant with p< 0.001.

Table 4: Association of Grade of PCO with single pulse energy used

Grade	N	Mean single pulse energy (mJ)	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
1	8	1.200	1.200	1.200
2	28	1.307	1.216	1.398
3	34	1.447	1.342	1.552
4	30	1.620	1.516	1.724
Total	100	1.200	1.200	1.200

Maximum single pulse energy is required for Grade 4(1.62mJ) with 95% confidence interval of (1.5-1.7) and least is for grade 1 (1.2mJ) with confidence interval of (1.2-1.2).
Which is statistically significant (p<0.001).

Table 5: Association of Type of PCO with single pulse energy used

Type of PCO	N	Mean single pulse energy(mJ)	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Membranous	54	1.389	1.312	1.466
Fibrous	27	1.489	1.368	1.610
Fibro-membranous	19	1.516	1.367	1.664
Total	100	1.440	1.381	1.499

Maximum single pulse energy is required for fibro-membranous type (1.516mJ) with 95% confidence interval of (1.3-1.6) and least is for membranous (1.38mJ) with confidence interval of (1.3-1.4).

Table 6: Association of pre laser vision with total energy used

Pre laser vision	N	Mean total energy (mJ)	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
HM- to 1/60	6	47.8	41.4	54.1
2/60 to 6/60	50	39.6	36.4	42.8
6/36 to 6/18	42	22.7	19.3	26.0
6/12 to 6/6	2	7.8	15.0	30.6
Total	100	32.4	29.5	35.2

Maximum energy used (47.8mJ) for patients with lesser vision (HM- to 1/60).
There is a statistically significant association between pre laser vision with the mean total energy used (p<0.001).

Table 7: Comparison of pre laser vision with the post laser vision

Pre laser vision	Post laser vision			Total
	2/60 - 6/60	6/36 – 6/18	6/12 - 6/6	
HM- to 1/60	4 66.7%	2 33.3%	0 .0%	6 100.0%
2/60 to 6/60	8 16.0%	26 52.0%	16 32.0%	50 100.0%
6/36 to 6/18	0 .0%	15 35.7%	27 64.3%	42 100.0%
6/12 to 6/6	0 .0%	0 .0%	2 100.0%	2 100.0%
Total	12 12.0%	43 43.0%	45 45.0%	100 100.0%

Maximum number of cases are in pre laser vision between 2/60 to 6/60 (50 cases), among them 52% improved to 6/36- 6/18 and 32% improved to 6/12 to 6/6 and 16% remained in same group.
There were only 2 patients before laser in the group 6/12 to 6/6 and it is increased to 45 after the Nd YAG laser capsulotomy in the same group.

Table 8: Association of complications of Nd YAG capsulotomy with total energy used

Complication	N	Mean total energy (mJ)	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Nil	68	32.2	28.8	35.5
IOP spikes	20	32.3	25.9	38.7
IOL pitting	6	29.0	19.0	38.9
Uveitis	4	32.4	10.8	75.6
Cystoid macular edema	1	42.0	.	.
Ant Hyaloid face rupture	1	57.6	.	.
Total	100	32.4	29.5	35.2

The complications such as IOP spikes, uveitis, hyaloid face rupture, IOL pitting, CME are common with higher total laser energy levels.

Table 9: Association of complications of Nd YAG capsulotomy with single pulse energy used

grade	N	Mean single pulse energy(mJ)	95% Confidence Interval for Mean	
			Lower Bound	Upper Bound
Nil	68	1.429	1.358	1.501
IOP spikes	20	1.500	1.356	1.644
IOL pitting	6	1.300	1.043	1.557
Uveitis	4	1.500	.949	2.051
Cystoid macular edema	1	1.200	.	.
Ant Hyaloid face rupture	1	1.800	.	.
Total	100	1.440	1.381	1.499

There is no statistically significant association between complications and single pulse energy used.

Table 10: Association of complications of Nd YAG capsulotomy with grade of PCO

Grade	Complications						Total
	Nil	IOP spikes	IOL pitting	Uveitis	Cystoid macular edema	Ant Hyaloid face rupture	
1	6 75.0%	1 12.5%	0 .0%	1 12.5%	0 .0%	0 .0%	8 100.0%
2	17 60.7%	8 28.6%	2 7.1%	1 3.6%	0 .0%	0 .0%	28 100.0%
3	24 70.6%	5 14.7%	4 11.8%	1 2.9%	0 .0%	0 .0%	34 100.0%
4	21 70.0%	6 20.0%	0 .0%	1 3.3%	1 3.3%	1 3.3%	30 100.0%
Total	68 68.0%	20 20.0%	6 6.0%	4 4.0%	1 1.0%	1 1.0%	100 100.0%

Complications like IOP spikes found more in grade 2 PCO cases, IOL pitting in grade 3 cases, we found one case of CME and one case of anterior hyaloid face rupture which is seen in Grade 4 PCO cases.

DISCUSSION

Out of 100 patients' maximum number are in membranous (54%) followed by fibrous (27%) and least is fibro-membranous (19%). Among membranous subtype a greater number of patients belong to Grade 2(48.1%). In patients with Fibrous subtype maximum patients presents with Grade 4(59.3%). Sever PCO (grade 4) were about 30%, moderate (grade 2 and 3) were 68% and mild (grade 1) were 8%.

In a retrospective study on 215 eyes with PCO, Bhargava et al found that different PCO subtypes required different initial and total laser energy levels depending on thickness of the posterior capsule (1.8, 3.1 and 2.7 mJ for membranous, fibrous, fibro-membranous opacities respectively). The authors recommended lower single pulse energy levels rather than higher total energy in order to minimize the rate of complications.

In our study maximum energy is required for grade 4(46.6 mJ +/- 11.2mJ) and least is for grade 1(9.7+/-3mJ) which is statistically significant.

The starting mean initial energy in the present study was 1.2 mJ and 1.8 mJ for membranous and fibrous forms of PCO respectively which is not significant, but There was a significant difference ($P < 0.001$) in the total laser energy levels required to create capsulotomy in fibrous and membranous subtypes of PCO. Energy is required for fibrous (39.2mJ +/- 14.8 mJ) and for membranous (26.7mJ+/-8.2mJ)

The complications such as IOP spikes, uveitis, hyaloid face rupture, IOL pitting, CME are common with higher total laser energy levels. Single case of anteriorhyaloid face rupture was noted with highest energy used 57.6 mJ.

CONCLUSION

More number of patients presented with membranous followed by fibrous and least is fibro-membranous, among membranous subtype a greater number of patients belong to Grade 2, Whereas in patients with Fibrous subtype maximum patients presents with Grade 4.

More number of patients presents with grade 3 and least by grade 1, energy required for grade 4 significantly high compared to grade 1. Grade and Type of PCO significantly influenced total and single pulse laser energy levels required for capsulotomy.

Whereas Complications such as IOL pitting, uveitis, IOP elevation, hyaloid face rupture and CME was significantly more common when total laser energy was higher, complications like IOP spikes found more in grade 2 PCO cases, IOL pitting in grade 3 cases, one case of CME and one case of anterior hyaloid face rupture which is seen in Grade 4 PCO cases.

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