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Effect of Neodymium-YAG Laser Posterior Capsulotomy on Intraocular Pressure

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ABSTRACT

Background: Posterior capsule opacification (PCO) also known as Secondary cataract is the most common complication following cataract surgery. It can occur between few months and many years after implantation of intraocular lenses (IOLs), with incidence figures ranging from <5% to as high as 50%.

Objective: The aim of this study was to determine the frequency of intraocular pressure elevation after Nd: YAG laser posterior capsulotomy for treatment of PCO.

Patients and Methods: A prospective non-randomized study that was conducted at Al Zahraa University Hospital. The study included a total of 40 eyes of 31 patients. All patients underwent Nd: YAG laser posterior capsulotomy. Patients were followed up at 4 hours, 1 day, 1 week and 1 month after laser capsulotomy. Nine cases were bilateral, 15 were males (48%) and 16 were females (52%).

Results: The majority of patients (90%) showed significant improvement in visual acuity after capsulotomy and about 87.5% of patients had final BCVA of 6/6-6/12, visual acuity after 24 hours was 6/9 in 20 eyes (50%) and 20 eyes (30%) had VA of 6/12. All the 40 patients had visual acuity improvement of 1 or more lines after capsulotomy. No one had further decline in visual acuity after capsulotomy.

Conclusion: The present study depicts the Nd: YAG laser capsulotomy as a good, successful treatment of PCO, because it was found to be modern, non-invasive, effective mode of treatment of PCO with lesser complications and it does not require hospitalization.

Keywords: Neodymium-YAG, Laser Posterior Capsulotomy, Intraocular Pressure.

INTRODUCTION

Posterior capsular opaification (PCO) causes decreased vision, glare and other symptoms similar to that of original cataract. It causes reduction in visual acuity and contrast sensitivity by obstructing the view or by scattering the light that is perceived as glare by the patient. It also decreases the field of view during therapeutic and diagnostic procedures and also causes uniocular diplopia [(1)].

There are three main sources of cells with a potential to cause opacification of capsular bag. 1-Cuboidal epithelial cells lining the anterior capsule these have no propensity for migration, they undergo fibrous metaplasia and proliferate in situ. 2-The cells at the equatorial lens bow have an increased level of mitotic activity. These cells are migratory; therefore they grow along the posterior capsule giving rise to bladder cells. 3-Finally, the residual cortical fibers from the equatorial lens bow become dislodged and float freely with in the bag. They may remain localized or migrate centrally into the visual axis. Elsching's pearls, posterior capsular wrinkling and fibrosis are various types of PCO. The central part of posterior capsule is opened either surgically or using the YAG laser which is considered as the standard treatment. Surgical capsulotomy may cause drastic complications as endopthalmitis [(2)].

Neodymium-doped yttrium aluminum garnet (Nd: YAG) laser capsulotomy, which was first described in 1980, is an effective technique and so-called gold standard to treat visually significant posterior capsular opacification (PCO) in pseudophakic eyes [(3)]. Several Nd: YAG laser techniques have been described for posterior capsulotomy in patients of PCO. The two posterior capsulotomy techniques most commonly used nowadays are cruciate technique and circular techniques [(1)].

A number of complications can occur after YAG laser capsulotomy such as elevation of intraocular pressure, rupture of anterior vitreous face, damage to intra ocular lens, hyphema, acute iritis, and cystoid macular edema (CMO). Unusual complications include corneal endothelial damage, macular hole, vitreous hemorrhage, retinal detachment, macular hemorrhage and endophthalmitis [(4)]. Raised intraocular pressure (IOP) is considered as the frequent complication of Nd: YAG laser posterior capsulotomy but usually it is a transient complication [(5)].

The increase in intraocular pressure (IOP) after Nd: YAG capsulotomy is due to reduced outflow facility because of trabecular meshwork blockage by the capsular debris and vitreous particles floating in the anterior chamber [(6)]. It is reported that the higher the laser energy and the higher the number of laser pulses, the higher the incidence of IOP elevation. This rise in IOP may be significantly high and may threaten the vision [(7)].

AIM OF THE WORK

The aim of this study was to determine the frequency of intraocular pressure elevation after Nd: YAG laser posterior capsulotomy for treatment of PCO.

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PATIENTS AND METHODS

This study was prospective non-randomized study that was conducted at Al Zahraa University Hospital between November, 2018 and April, 2019. The study included a total of 40 eyes of 31 patients. All patients underwent Nd: YAG laser posterior capsulotomy. Patients were followed up at 4 hours, 1 day, 1 week, and 1 month after laser capsulotomy. Nine cases were bilateral, 15 were males (48%) and 16 were females (52%). All eyes were diagnosed as PCO with significant reduction of visual acuity.

Ethical consideration and Written informed consent:

An approval of the study was obtained from Al-Azhar University Academic and Ethical Committee. All patients signed an informed written consent for acceptance of the operation.

Methods:

All patients will be subjected to the following:

1. Detailed history taking (age, gender, time interval after cataract surgery, etc…)
2. Complete ocular examination including uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA).
3. Slit-lamp examination for the anterior segment.
4. IOP measurement using the Goldmann applanation tonometer (GAT).
5. Indirect opthalmoscopy.

Inclusion criteria:

1. Significant PCO impairing visual acuity.
2. History of cataract surgery is of at least 3 months.
3. Pre-laser IOP (baseline IOP) is between 10-20 mmHg.
4. Quiet eye with no inflammation.
5. Cooperative patients.

Exclusion criteria:

1. Patients having any anterior segment pathology like conjunctivitis, keratitis, symblepharon, corneal degeneration, corneal dystrophy, anterior uveitis.
2. Patients having glaucoma, vitritis or any inflammation.
3. Patients operated for traumatic cataract.
4. Patients with dislocated IOL or decentered IOL.
5. History of cataract surgery less than 3 months.

Pre-Laser Medication

Dilatation of the pupil was done by using Tropicamide 1% together with 5% Phenylephrine eye drops.

Procedure

- The patient was introduced to the equipment in a reassuring way
- The chair was adjusted, and the head was gently placed in front of the laser on chin rest & head strap was applied
- The slit lamp was focused and the YAG was switched on.
- The patient was instructed to fix to the fixation light by the other eye.

The capsulotomy was done. A Carl Zeiss Visulas YAG III Nd-YAG Laser was used with the laser beam retro-focused by 0.1 mm behind the helium–neon beam focused on the posterior capsule and used pulses with the energy level ranging from 0.8 mJ to 5.0 mJ based on the density of the opacified capsule. The size of capsulotomy should match the size of the pupil in the physiological state. Focusing with the help of slit lamp, optical beam was focused on the posterior capsule and laser shots were given. To begin a capsulotomy, lowest energy/pulses was used and when more energy was required, it was gradually increased.

- Energy and shots were recorded for every patient.

Figure (1): Lazser apparatus

Post Laser Follow-Up:

Visual acuity was recorded for distant vision immediately post-operative

- Follow up visits were done after 1day, 1 week, 1 month.
- During each follow up visit patient was subjected to:

- UCVA&BCVA
- Slit lamp examination of the cornea and for the evidence of iritis.
- IOP is recorded by applanation tonometry
- Indirect ophthalmoscopy for any Post segment complications.

The patient was given the following treatment:

- Topical timolol 0.5% b.i.d. for 1 week.
- Topical combination of dexamesathone and tobramycin 1 q.i.d. for 1 week.

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage.

The following tests were done:

- Independent-samples t-test of significance was used when comparing between two means.
- Chi-square (x^2) test of significance was used in order to compare proportions between two qualitative parameters.
- The confidence interval was set to 95% and the margin of error accepted was set to 5%. The p-value was considered significant as the following:
- Probability (P-value)
  - P-value < 0.05 was considered significant.
  - P-value < 0.001 was considered as highly significant.
  - P-value > 0.05 was considered insignificant.

RESULTS

After a short-term study of 5 months, the following observations are made. Cases were divided according to age/sex wise and also according to duration between cataract extraction and development of posterior capsular opacification.

Table (1): Sex distribution of the study population

Sex	Number of cases	Percentage (%)	M:F ratio
Male	**15**	**48 %**	**0.9:1**
Female	**16**	**52 %**	**0.9:1**
Total	**31**	**100**	

In our study out of patients 15 were males and 16 were females.

Table (2): Laterality of PCO

Laterality	No. of cases	Percentage (%)
Right eye	**22**	**55 %**
Left eye	**18**	**45 %**
Total	**40**	**100 %**

Among the study population, **22 (55 %)** cases involved the right eye and**18 (45%)** cases involved the left eye.

Maximum numbers of cases need YAG laser capsulotomy between the periods of 1 year – 2 years. This table showed that the interval between cataract surgery and laser capsulotomy ranged from 3 months to > 3 years. Most of them fifteen eyes (38 %) had a history of cataract surgery 1 year – 2 years before YAG capsulotomy. In. Maximum interval from cataract surgery to capsulotomy was 10 Years in a 70 year old female.

Incidence of PCO needing YAG laser capsulotomies was higher in young age group than old age groups (Table 3).

Table (3): Relation between age of the patient at cataract surgery and the development of posterior capsular opacification needing ND-YAG laser posterior capsulotomy

		Interval after surgery
Age 11-20	Mean ± SD Range (Min- Max)	1.29 ± 1.00 0.58 – 2
Age 21-40	Mean ± SD Range (Min- Max)	1.39 ± 1.40 0.58 – 3
Age 41-60	Mean ± SD Range (Min- Max)	2.92 ± 1.55 1 – 6
Age >60	Mean ± SD Range (Min- Max)	3.75 ± 2.87 2 – 10
Test value **P-value**		**1.429•** **0.261 (NS)**

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)

•: One Way ANOVA test

Table (4): Types of posterior capsular opacification

Types of PCO	No. of eyes	Percentage (%)
Elschnig's pearls	**5**	**13**
Fibrous	**29**	**72**
Wrinkling	**6**	**15**
Total	**40**	**100**

Among the study population, **72 % (29 out** of **40)** had fibrous type of PCO, **13 % (5** out of **40)** had Elschnig's pearls type of PCO and **15 % (6** out of **40)** had wrinkling type of PCO as shown in table (4) and figures (2 & 3).

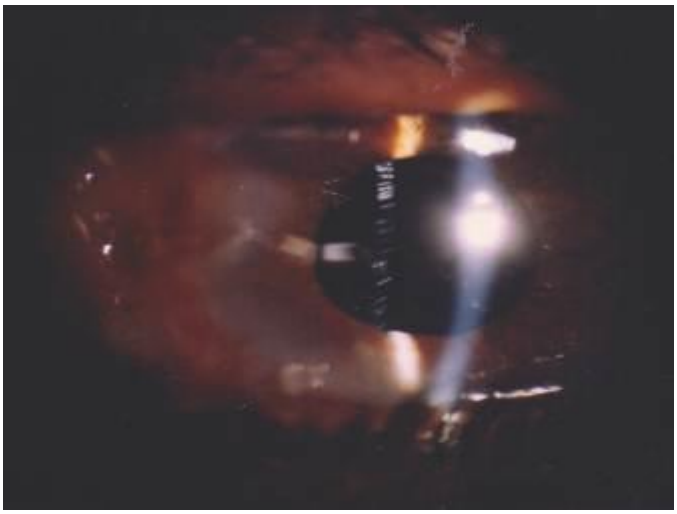

Figure (2): Wrinkling type of posterior capsular opacification

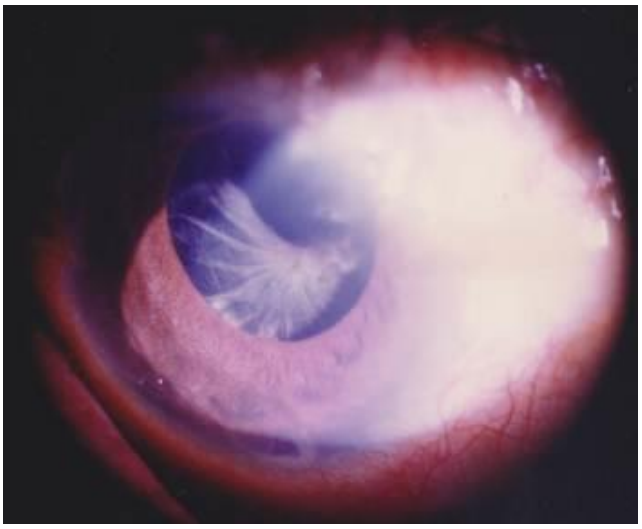

Figure (3): Fibrotic type of posterior capsular opacification

Table (5): Relation between the type of posterior capsular opacification and the number of shots, pulse energy and the total energy power

		Wrinkles	Elshing pearls	Fibrosis	Test value•	P-value	Sig.
		No.= 4	No.= 3	No.= 19			
No. of shots	Mean±SD Range	28.00 ± 10.00 18 – 62	37.00 ± 11.03 23 – 56	45.84 ± 12.08 15 – 68	4.132	0.029	S
Pulse energy (mJ)	Mean±SD Range	2.35 ± 0.34 2.2 – 3	2.67 ± 0.76 2 – 3.5	3.55 ± 0.83 1.4 – 4.5	4.925	0.017	S
Total energy (mJ)	Mean±SD Range	80.54 ± 43.26 43.2 – 186	105.83 ± 69.15 57.5 – 196	150.20 ± 50.28 21 – 232	3.562	0.045	S

P-value >0.05: Non significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)
•: One Way ANOVA test

Table (6): BCVA before laser and during the follow up period

BCVA (Snellens)	Pre-laser	4 hours	1 day	1 week	1 month
6/6	**0**	**0**	**3**	**3**	**3**
6/9	**0**	**4**	**20**	**20**	**20**
6/12	**6**	**20**	**12**	**12**	**12**
6/18	**8**	**8**	**4**	**4**	**4**
6/24	**8**	**4**	**1**	**1**	**1**
6/36	**6**	**4**	**0**	**0**	**0**
6/60	**6**	**0**	**0**	**0**	**0**
3/60	**6**	**0**	**0**	**0**	**0**
1/60	**0**	**0**	**0**	**0**	**0**
Total	**40**	**40**	**40**	**40**	**40**

The Nd: YAG laser was effective in clearing pupillary opening in all 40 eyes (100%) in one session. None of the patients required retreatment. Post-laser 50 % of patients had BCVA 6/9 or more at 1 month follow up. 30 % of patients had BCVA 6/24 to 6/12. Only 3 % of patients had visual acuity improved to 6/24 (Tables 5 & 6).

In our study, pre-laser best corrected visual acuity ranged from CF3/60 to 6/12**.** Maximum patients achieved the final visual acuity of 6/9-6/12 (80 %) while 5 patients achieved final snellen acuity of 6/18-6/24 (12.5%). In our study, we did not observe decrease in visual acuity than pre-laser visual acuity in any case. Vision was improved in all patients at least by one Snellen's line. This is probably due to exclusion of cases from study with pre-existing ocular diseases, which could prevent improvement in visual acuity (Table 7).

Table (7): Mean BCVA and p value before and after YAG capsulotomy

BCVA	Pre-laser	24 hours	1 day	1 week	1 month
Mean ± SD	4.44 ± 3.43	4.44 ± 6.46	4.44 ± 7.00	4.44 ± 7.00	4.44 ± 7.00
p-value (vs pre-laser)	--	1.000	1.000	1.000	1.000

Effect of Nd: YAG posterior capsulotomy on IOP

Elevation of Intraocular Pressure after Nd: YAG Laser Posterior Capsulotomy. Intraocular pressure was recorded within 4 hours, 1day, 1 week, 1 month and the results are tabulated in table (8).

Table (8): IOP after YAG posterior capsulotomy during the follow up visits

Rise in IOP (mm Hg)	**4 hour**	**1day**	**1 week**	**1 month**
No change	0	15	34	37
1-5	34	23	6	3
6_10	6	2	0	0
11_15	0	0	0	0
>15	0	0	0	0
Total	40	40	40	40

Among these 85 % patients showed rise in IOP that was ≤5 mm Hg while 15 % of the patients had a rise > 5 mm Hg. However the rise in IOP was transient and only 6 patients showed increased IOP at 1 week post-laser (Table 8).

In our study, 34 patients had IOP greater than 5 mm of Hg within 4 hours and 23 patients had IOP greater than 5 mm of Hg within 24 hours and only 6 patients had IOP greater than 5 mm of Hg within one week. In our study, we observed that there was statistically significant increase in IOP at 1 and 4 hour post-laser when higher energy was used. In the present study, though there was transient rise in IOP at the end of 4 hours, there was no much change in IOP at the end of 1 week. In addition, the increase in IOP was significantly related to the IOP measurement 4 hours after the capsulotomy ($p<0.001$, $r=0.512$), whereas difference between baseline and final IOP at 1 week was not significant as shown in tables (8 & 9).

Table (9): Mean IOP elevation in respect to time interval after YAG-laser capsulotomy

AT (mmHg)	Pre-laser	4 hour	Day 1	1 week	1 month
Mean ± SD	12.42 ± 2.66	15.58 ± 2.67	13.15 ± 2.01	12.27 ± 2.32	12.27 ± 2.65
P-value (vs pre-laser)	--	<0.001	0.034	0.294	0.212
'F'	F= 48.141, P < 0.001				

Level of Energy (mJ) used

Table (10): Correlation between energy used and rise in IOP after Nd: YAG posterior capsulotomy (n=40)

Rise in IOP	No change	1-5 mmHg	6-10 mmHg	11-15 mmHg	>15 mmHg	Total
Level of Energy ↓ 1.2 _ 1.5	0	3	0	0	0	3
1.6 –1.8	0	0	0	0	0	0
1.9 _2.1	0	3	0	0	0	3
2.2 _2.4	0	7	0	0	0	7
2.5_2.7	0	5	0	0	0	5
2.8_3.1	0	6	0	0	0	6
3.2_3.4	0	3	4	0	0	7
3.5_3.7	0	3	0	0	0	3
3.8_4.1	0	0	2	0	0	2
4.2_4.4	0	0	2	0	0	2
4.5_4.7	0	0	2	0	0	2

Table (11): Statistics, Correlation between energy used and rise in IOP after Nd: YAG posterior capsulotomy

	Pulse energy (mJ)	
	R	P-value
No. of shots	0.584**	0.002
Total energy (mJ)	0.836**	0.000
Pressure		
Pre-laser	-0.296	0.143
4 hours	0.713**	0.000
1 day	0.502**	0.009
1 week	0.699**	0.000
1 month	0.442*	0.024

Most of the capsulotomies were done at the level of energy between 2.2 mJ to 2.4 mJ as shown in table (10). It consisted of 40 eyes. 3 capsulotomies were done at the level of 1.2 mJ to 1.5 mJ, while 11 capsulotomies were done at the level of 2.5 mJ to 3.1 mJ. The minimum amount of energy used was 1.2 mJ and maximum amount of energy used was 4.7 mJ.

In our case series, 16 patients required total energy between 30 mJ and 90 mJ. A total of 24 patients required more than 90 mJ, and 16 patients required more than 130 mJ. The maximum amount of energy used was 232 mJ and minimum was 21 mJ. The higher the total energy power used during Nd: YAG laser posterior capsulotomy, the higher Iop elevation during the follow up visits (Table 11).

Table (12): Staticitics, Correlation between total energy used and rise in IOP after Nd: YAG posterior capsulotomy

	Total energy (mJ)	
	R	P-value
No. of shots	0.909**	0.000
Pulse energy (mJ)	0.836**	0.000
Pressure		
Pre-laser	-0.259	0.202
4 hours	0.810**	0.000
1 day	0.725**	0.000
1 week	0.805**	0.000
1 month	0.695**	0.000

Table (13): Complications of YAG capsulotomy

Sl. No.	Complication	Number of Eyes	Percentage
1.	Rise in intraocular pressure (transient)	40	0 %
2.	Pitting of intraocular lens	7	100 %
3.	Iritis	3	17.5 %
4.	Hyphema	0	0
5.	Vitritis	0	7.5

Complications of Nd: YAG laser posterior capsulotomies in our study showed that there was IOP elevation in 40 eyes (100%), IOL pitting in 7 eyes (17.5%) and Iritis in 3 eyes (7.5%). No hyphema, vitritis or posterior segment complications were reported.

DISCUSSION

Age and sex Distribution

The rate of opacification is more in younger age group and it declines with increasing age [8]. While **Schaumberg *et al.*** [9] found no association between age and sex of patients with the risk of secondary cataract. The present study showed that PCO was more common in the age group of 41-60 years, because of cataract surgery being performed more often in this age group.

Khan *et al.* [4] in their study found that, 67.2% were males wheras females were 32.8%. **Pratima *et al.*** [6] also found that 40 were male and 30 were female in his study. **Prempal *et al.*** [2] in his study found that 62% of cases were male while 38% were female. **Gore** in his study found that male patients were 61.5% and females were 38.5%. **Ram *et al.*** [10] in their study reported 95 males and 105 female while **Kumar *et al.*** [8] reported more 43% male and 57% female in their study group. Similarly, the present study also showed female preponderance, as out of 40 patients, who underwent laser capsulotomy, there were 19 males (48%) and 21 female (52%). The male to female ratio was found to be 0.9:1

Duration between surgery and PCO:

Development of PCO is found to be high within 0-2 years of cataract surgery. **Gogoi *et al.*** [11] in their review article demonstrated that PCO is the commonest complication of cataract surgery occurring in up to 50% of patients after 2–3 years of surgery.

It has been observed that most of the patients presented with visually significant PCO within 12-24 months of the cataract surgery (38%), closely followed by 27% of the patients who developed PCO > 36 months of cataract surgery.

Types of posterior capsular opacification:

Richter *et al.* [12] studied the relationship of capsulorhexis size with the occurrence of PCO and concluded that capsulorhexis with a slightly smaller diameter than the IOL optic appears to be better than a large-size capsulorhexis in reducing the incidence of PCO.

Rajesh *et al.* [13] reported that posterior continuous curvilinear capsulorhexis with optic capture of the heparin-coated IOL was successful in preventing secondary opacification of the visual axis in pediatric cataract cases.

Ram *et al.* [10] found in their study that capsular fibrosis was the most common type of PCO that was present in 86% of the case. In present study the thick fibrotic type of PCO was the most common type of PCO observed (72 %) closely followed by wrinkling type of PCO (15 %), while Elschnig's pearls type of PCO were seen least commonly 13 %.

Visual Outcome

In ophthalmic practice, importance is given to visual acuity when assessing a patient's visual outcome in relation to planned or executed procedures.

Result of various studies showed that YAG laser capsulotomy is one of the best method of treatment of posterior capsule opacification. Though it had its associated complication and risk but in comparison to visual outcome, complication rates are very less. **Keates *et al.* [14]** reported improvement in visual acuity in 87.2 % of cases, with 82.9 % achieving a visual acuity of 6/12 or better and cumulative complication in the laser treated population were very low (CME 2.3%, Secondary glaucoma 3.6%, retinal detachment 0.4%, overall rate 4.8%).

Roger [15] studied 526 subjects who were treated with the laser, 87.8% had improved vision, with 82.9% achieving a visual acuity of 20/40 or better.

Improvement in visual acuity is the primary endpoint for successful neodymium: YAG (Nd: YAG) laser posterior capsulotomy for posterior capsule opacification.

Increased Intraocular Pressure

The common causes for raised IOP were deposition of debris in trabeculum, pupillary block and inflammation of iris and ciliary body with angle closure **[16].** The rise of intraocular pressure was most probably because of presence of cells and flare in the anterior chamber blocking the trabecular meshwork. Most of the cases returned to pre-laser state since all the cases were given topical steroid drops **[17].** IOP rise is the most common complication of ND: YAG Capsulotomy in our study. The IOP rise after Nd: YAG laser posterior capsulotomy may be absent or transient or permanent. The pressure spikes are recorded at 3 to 4 hours after laser treatment and it returns to within 5 mm Hg of pre-laser values by 24 hours.

Total cumulative energy for capsulotomy

The laser energy used for capsulotomy relates directly to density of posterior capsular opacification as observed by **Kumar *et al.* [8].** The total cumulative energy (energy per pulse in mj x number of pulses) required to perform adequate capsulotomy ranged from 20 to 232 mj. The mean total energy delivered was 126.23 mj but maximum patients required less than 130 mj for capsulotomy & in those who required more than 130 mj, risk of rise in Intra ocular pressure was more. The total amount of laser energy used was comparatively more in patient with moderate and thick fibrotic capsular opacification, which is in accordance with the previous studies **of Kumar *et al.* [8].** So cumulative energy was nearly equal in both of our study and other studies. In another study by **Richter *et al.* [12]** they found that maximum patients required less then 200 mj for capsulotomy & in those who required more than 200 mj risk of rise in intra ocular pressure was more.

Complications following Nd: YAG laser posterior capsulotomy

In this present study, incidence of various complications after Nd: YAG laser posterior capsulotomy were; raised intraocular pressure in all, mild anterior uveitis in 3 cases (7.5 %), intraocular lens pitting in 7 cases (17.5 %). None of the cases showed corneal damage, hyphaema, cystoid macular oedema, endophthalmitis or retinal detachment. In the present study, Patients had iritis after YAG laser capsulotomy manifested as cells and flare in anterior chamber on slit-lamp examination. They were given topical steroid and reaction had subsided leaving no delayed complication. In the present study, intraocular lens pitting was seen in cases of thick PCO with more number of shots. However, there was no decrease or disturbance in visual acuity with only pitting of IOL. None of the cases showed corneal burn or hyphaema. This was most probably because of high skill with proper focusing and exclusion of uncooperative patients.

CONCLUSION

- The most common post-operative complication of cataract extraction was posterior capsular opacification, which in turn caused deterioration of visual acuity.
- The Nd: YAG laser capsulotomy is a safe and effective method to treat posterior capsular opacification. It is a non-invasive and avoids all the complications of surgical capsulotomy.
- IOP rise was the most frequent complication of Nd: YAG laser.
- Rise in IOP was maximum at 4 hours after procedure, which was normalized within 7 days after procedure.
- There was a positive association between the amounts of total energy delivered during Nd: YAG laser posterior capsulotomy and mean IOP elevation especially in the immediate post procedure period (4 hours).
- The total amount of laser energy for successful capsulotomy was directly proportionate with the density of PCO.

- Higher no. of laser shots and higher amount of total laser energy led to transient rise in intraocular pressure.
- It was found that rise of IOP was usually in patient who received more number of shots and hence more cumulative laser energy.

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