Original articles

Estimation of mean ND: Yag laser capsulotomy energy levels for membranous and fibrous posterior capsular opacification

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Abstract

Introduction: Posterior capsule opacification (PCO) is a visually-disabling complication of cataract surgery.

Objective: To estimate energy levels for capsulotomy in various subtypes of PCO (membranous, fibrous and fibro-membranous).

Materials and methods: A total of 215 patients with PCO were randomly selected and evaluated for Nd: Yag laser capsulotomy, after a quiet post-operative course of 3 months. The ocular area was arbitrarily divided into three zones: YAG zone (3mm), Optical zone (6 mm) and the peripheral zone (12mm). A colour code was assigned to the subtype of PCO in these zones: fibrous green and membranous blue. The type of PCO in each quadrant of YAG zone was estimated in percentage.

Results: The statistic mean values of initial energy levels were 1.80 mJ for membranous PCO, 3.17 mJ for fibrous PCO and 2.73 mJ for fibro-membranous PCO. The mean summated energy levels for membranous PCO was 22.80 mJ for membranous PCO, 80.06 mJ for fibrous PCO and 80.48 mJ for fibro-membranous type.

Conclusion: Colour coding is extremely helpful for quantification of the type of PCO and in deciding the initial energy level necessary to create capsulotomy. Fibro-membranous PCO required more summated energy despite a lower starting energy. Therefore, we recommend firing the initial shot in fibrous portion in case of fibrous-membranous type of PCO.

Key-words: Nd: Yag laser, intra ocular lens (IOL), posterior capsule opacification

Introduction

Expectations of patients receiving modern cataract surgery are becoming similar to patients with refractive surgery; they expect almost perfect result, often emetropia.

PCO is the most common visually disabling sequel of modern cataract surgery and has important medical, social and economic implications (Hollick et al, 1998).PCO reduces visual acuity, contrast sensitivity and causes uniocular diplopia. It also decreases field of view in therapeutic and diagnostic procedures (Apple et al, 1992; Tan et al, 1998; Paulson & Sjostrand, 1980).

Sundelin and Sjostrand have defined visually significant PCO as a decrease in post-operative best corrected visual acuity by two Snellen lines (Sundelin & Sjostrand, 1999).

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Nd: YAG laser capsulotomy has now replaced surgical capsulotomy for PCO management (Murril et al, 1995). However, surgical aspiration of Elschnig pearls seems to be an alternative to Nd: YAG laser capsulotomy in myopic eyes (Janknecht & Funk, 1992).

Schaumberg et al (1998) conducted an important meta-analysis of published articles on PCO and noted that rate of PCO remains unexpectedly and unacceptably high, still over 25% during 5 year postoperative follow up. With the advent of phacoemulsification, foldable and surface modified IOL's, changes in shape of IOL and recognition of importance of thorough cortical clean up, there has been a reduction in the incidence of PCO (Chitkara & Somerton, 1997).

Nd: YAG laser emits pulses of 2-3 ns and energy at 1064 nm wavelength. A state of high pressure and temperature called plasma is produced causing photo disruption of tissues confined in a narrow space (Steinert & Puliafito, 1983). Shock wave generated by plasma expansion causes the incision effect (Belcher & Mainster, 1985).

Trinavarat et al (2001) evaluated Neodymium: YAG laser damage threshold of foldable intraocular lenses and found that 50% incidence damage threshold in all IOL's was below the energy level normally used to perform capsulotomy. The risk of IOL damage could be minimised by setting the laser at the lowest possible energy and focusing the laser beam beyond the posterior capsule.

Materials and methods

A total of 215 patients with PCO underwent Nd:YAG laser capsulotomy for age related cataract between 2005 to 2008, following small incision cataract surgery (SICS). A large burden of cataract and shortage of eye surgeons in the subcontinent, offers manual SICS an economic advantage over phacoemulsification as a preferred surgical technique of cataract extraction (Natchair & Dabral, 2000).However, there are no published randomised controlled trials comparing phacoemulsification and manual SICS for PCO development (Medline search).

Patients with traumatic, paediatric cataract, diabetic retinopathy, posterior capsule rent, RD in fellow eye and past history of vitreo-retinal surgery were excluded from the study.

As a rule, patients with PCO were considered for capsulotomy after a minimum period of 3 months following uneventful cataract surgery. A written consent was taken from all patients and risks and benefits of the procedure explained. Best corrected visual acuity (BCVA), Indirect Ophthalmoscopy, 90D examination and Slit-lamp examination was done in all patients. IOL fixation was noted after fully dilating the pupil.

Due to lack of sophisticated equipment's to measure thickness of PCO subtypes, we divided the ocular area into three zones (FIGURE A) and assigned a colour code (Fibrous green and membranous blue) to the subtype of PCO in each quadrant. Each quadrant in a zone is equivalent to 25 % area. The type of PCO in YAG zone was estimated in percentage. A PCO subtype occupying 75% area or more was taken as the predominant subtype for that eye.

Figure A. The YAG LASER Nomogram)

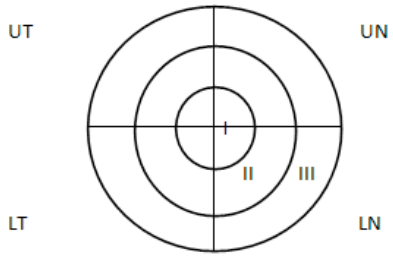

Figure A YAG LASER NOMOC

ZONE I YAG LASER ZONE (3mm) YZ
ZONE II OPTICAL ZONE (6mm) OZ
ZONE III PERIPHERAL ZONE (12mm) PZ

Fibrous

MEMBRANOUS

Capsulotomy was performed using Abraham's lens with Q-switched Nd: YAG LASER (Visulas YAG II^{plus}, Carl Zeiss, Germany).The optical centre of the IOL was matched with the centre of the opening, not exceeding greater than 50% of optical zone. The initial energy levels (0.3 to 10 mJ) and the summated energy (E) were noted in each patient.

We evaluated patients on day 1, 7, 1M, 3M, 6M, I2M, 24M and 36M. On each visit, BCVA, IOP by Applanation, Slit lamp examination with 90D and Indirect Ophthalmoscopy was done. 21 patients were lost in follow up by two years and another 11patients by three years.

Chi-square test was used to analyse the data as there were more than two variables in the study. The number of valid cases was 215. 'P' value was calculated at 1% and 5 % levels. 'P' value less than 0.001 at 1% and less than 0.005 at 5% implied that data was statistically significant. Factors likely to influence PCO development were analysed using Z statistic and Z value was calculated at 95% confidence interval.

Results

The statistic mean age of patients was 60.4372. The range was (45-83).There was a slight preponderance of females in our study with a male female ratio of 0.733. The mean interval between surgery and onset of PCO was 12 months. The statistic mean follow up period was 30.130 months. An interesting observation made was that the summated energy level was least for in the bag fixated IOL'S whereas it was more for sulcus fixated and maximum for bag-sulcus fixated IOL's.

Membranous type of PCO required lower starting energy with a statistic mean of 1.8100. Fibrous type of PCO required higher starting energy with a statistic mean of 3.1777. The statistic mean for Fibromembranous PCO was 2.7306 (Table 3). The difference in initial energy level for types of PCO was statistically significant (p=0.00) at 1% level.

The mean summated (total) energy for membranous PCO was 22.8000 whereas mean summated energy for fibrous PCO was 80.06080 (Table 4). A paradox was observed! The summated energy for Fibro-membranous PCO had a statistic mean of 80.4857 despite lower mean starting energy. On application of Chi-square test, the difference in summated energy used for types of PCO was statistically significant (P=0.01).

The most common complication was IOP elevation seen in 15.3 % cases (Table 1). All patients were given Apraclonidine 0.5 % eye drops three times daily for three weeks. 2 patients developed permanent rise of IOP and were referred to glaucoma clinic. Iritis was seen in 12 % cases and was associated with higher summated energy levels. All cases of iritis resolved with topical instillation of corticosteroids.

Table 1: Initial Energy levels for types of PCO

Energy levels (mJ)	Membranous		Fibrous		Fibro-membranous	
	No of cases	%	cases	%	cases	%
0.3-2	38	95	2	1.9	19	26.4
2.1-4	02	5	71	68.9	40	55.5
4.1-6	0	0	26	25.2	13	18.1
6.1-8	0	0	3	2.9	0	0
8.1-10	0	0	1	1	0	0
Total	**40**	**100**	**103**	**100**	**72**	**100**

Table 2: Summated Energy Levels for type of PCO (mJ)

Energy Levels (mJ)	Membranous		Fibrous		Membranous+ Fibrous	
	No of cases	%	cases	%	cases	%
0-25	24	60	0	0	6	8.3
26-50	16	40	37	35.9	17	26.6
51-75	0	0	37	35.9	23	31.9
76-100	0	0	10	9.7	8	11.1
101-200	0	0	13	12.6	8	11.1
>200	0	0	6	5.8	10	13.8
Total	**40**	**100**	**103**	**100**	**72**	**100**

Table 3: Pre and Post YAG LASER BCVA

Complication	No of Cases = 215	Percentage
IOP elevation	33	15.3
Iritis	26	12
Retinal detachment	9	4.1
Hyaloid Phase rupture	27	12.5
IOL damage	18	8.3
Cystoid Macular Edema	6	2.7
Corneal burn	2	0.9

Table 4: Complications of YAG LASER capsulotomy

VISUAL ACUITY	Pre YAG Laser	Post YAG Laser
	n (%)	n (%)
<6/60	15 (7)	00(0.0)
6/60- 6/24	119(55.3)	3(1.4)
6/18 (P) -6/12	81(37.7)	9(4.1)
6/9 (P)- 6/6	00(0.0)	203(94.6)
TOTAL	215(100)	215(100)

Damage to IOL in form of pitting was seen in 8.7 % cases. Pitting was more common in bag fixated IOL's. The frequency of retinal detachment was 4.18 %. The statistic mean interval following capsulotomy and retinal detachment was 12.7 months. Only one patient with RD was myopic in our study. Only one patient with membranous type of PCO developed RD. Anterior hyaloid phase rupture was a relatively common finding seen in 12.5% cases. (Table 4)

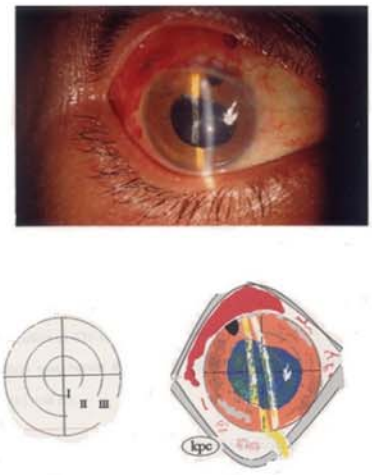

Figure 1 : MEMBRANOUS P.C.O.

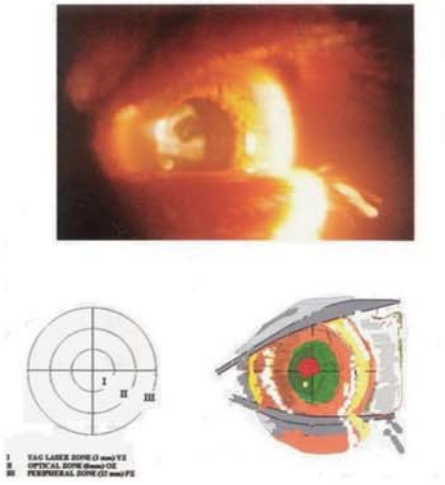

Figure 2 : CAPSULOTOMY IN FIBROUS P.C.O.

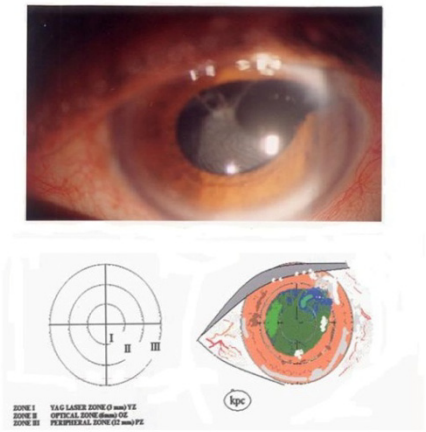

Figure 3 : FIBROUS P.C.O.

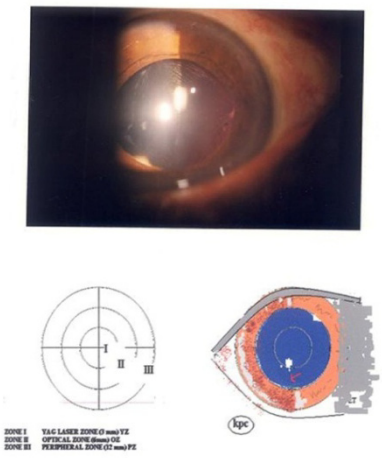

Figure 4 : MEMBRANOUS P.C.O.

Discussion

Singh et al (2000) found that sex of the patient did not affect the predictability of posterior capsule opacification post-operatively. However, preponderance of females in our study may be explained by the fact that rural women being more disadvantageous segment of Indian society have poor access to newer modalities of cataract surgery like phacoemulsification.

Tetz et al (2000) analysed energy levels for Nd: YAG laser capsulotomy for PMMA IOL's and found that sulcus fixated IOL's required higher energy. In our study, both sulcus and sulcus-bag fixated IOL's required higher energy. A comparable result. Higher summated energy levels for bag-sulcus fixated IOL's could be explained by the fact that difficulty in focusing laser beam due to slight IOL tilt, required more number of shots to create capsulotomy. Close proximity of IOL to posterior capsule in bag fixated lenses could account for pitting observed in bag fixation.

Till date, only a few studies have estimated the mean energy required for capsulotomy in various subtypes of posterior capsule opacification (Medline Search).

Auffarth et al (2000) analysed energy levels for capsulotomy in a series of 172 patients and found that the average total energy used was 12.7 +/- 9.4 mJ. In our study, the mean energy level for membranous PCO was 22.8 mJ, a comparable result. However in their study, 26 patients required a second a second Nd: YAG laser capsulotomy indicating Fibrous PCO requires more energy.

Khanzada and co-workers (2008) evaluated the complications during and following Nd: YAG laser posterior capsulotomy and found that on an average 24 pulses were required in creating an opening in the posterior capsule. The mean initial energy level in their study was 3.2 mJ and the mean summated energy level was 48.8 mJ. They results were not comparable with our study as the authors did not attempt to gauge thickness of PCO or differentiate between membranous and fibrous subtype.

Membranous PCO being thinner required lower starting (1.8 mJ) as well as total energy for capsulotomy as compared to thicker fibrous capsule (3.1mJ). The paradox that fibro-membranous PCO requiring higher total laser energy despite lower starting energy (2.7mJ) could be explained the fact that it was difficult to set the initial energy level. Fibro-membranous PCO has three zones namely fibrous, membranous and fibro-membranous junction. We set low energy level to fire shot at the fibro-membranous junction. This caused slight prolapse of anterior hyaloid phase, causing difficulty in focusing laser beam, and consequently, more energy to cut the fibrous part. Further studies aided by equipment's to gauge the thickness of the subtype of PCO may be required and may not result in the paradox observed. We therefore advise to fire

the shot of 3.1 mJ on fibrous part in case of fibro-membranous PCO.

Conclusion

We suggest that laser energy be set at lowest possible level and laser beam focused slightly beyond posterior capsule. An initial shot of1.8 mJ will crack most PCO of the membranous subtype and an initial shot of 3.1mJ, all fibrous PCO. In cases with fibro-membranous PCO, we recommend to fire the initial shot of 3.1mJ on the Fibrous portion to avoid prolapsed anterior phase interfering with focusing of laser beam and consequently, more energy to cut the fibrous part. Although, there is no internationally acclaimed system of quantifying PCO, colour coding appears to be simple, effective and practical and can be used by other researchers

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