Comparison of Nd: YAG (Neodymium-Doped Yttrium Aluminum Garnet) Laser Posterior Capsulotomy Techniques in The Treatment of Posterior Capsular Opacification

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ABSTRACT

Objective: To compare the safety and efficacy of different techniques of neodymium: yttrium-aluminum-garnet (Nd: YAG) laser posterior capsulotomy.

Study Design: Quasi-experimental study.

Place and Duration of Study: Combined Military Hospital Nowshera, from Aug 2015 to Mar 2017.

Methodology: A total of 120 patients fulfilling the inclusion criteria were allocated to three groups. Group-A (Circular-group, CG) patients were subjected to circular pattern capsulotomy, group-B (Hinged-group, HG) patients underwent hinged pattern capsulotomy and group-C (Modified-group, MG) had a circular pattern of Nd: YAG posterior capsulotomy along with vitreous strand cutting (modified round pattern). Primary outcome measures were the best-corrected visual acuity (BCVA), intraocular pressure (IOP) and annoying floaters at three-months follow up visits.

Results: The mean age of patients was 52.27 ± 5.65 years and there were 64 (53.3%) males and 56 (46.7%) females. The best-corrected visual acuity improved significantly (p<0.001) in the modified round pattern group compared to the other two groups at two weeks post-capsulotomy. Intraocular pressure remained unchanged among the three groups. Significantly fewer patients in the modified treatment-group experienced annoying floaters as compared to hinged and circular treatment groups [3 (7.5%) vs 9 (22.5%) vs 12 (30.0%) respectively, p=0.038].

Conclusion: Modified round pattern Nd: YAG laser posterior capsulotomy is a safe and effective method for treating posterior capsular opacification.

Keywords: Hinged capsulotomy, Posterior capsular opacification, Vitreous strand cutting, YAG laser capsulotomy.

How to Cite This Article: *Parveen S, Naeem S, Hanif K, Akbar B. Comparison of Nd: Yag (Neodymium-Doped Yttrium Aluminum Garnet) Laser Posterior Capsulotomy Techniques in the Treatment of Posterior Capsular Opacification. Pak Armed Forces Med J 2022; 72(1): 164-168. Doi: https://doi.org/10.51253/pafmj.v72i1.3697*

INTRODUCTION

Opacification of initially clear posterior capsules is quite common in the eyes after uncomplicated cataract surgery. However, the window period from surgery to development of significant posterior capsular opacification (PCO) varies. Different studies have described different incidence rate of posterior capsule opacification. Phacoemulsification is known to be linked with lower rates of PCO as compared to extra-capsular cataract surgery. According to a study, approximately 25% of the patients developed significant PCO within 5 years of extra-capsular cataract extraction.[1] Many studies have revealed the underlying pathogenetic factors culminating in the formation of PCO.[2,3] A better understanding of the underlying mechanism has paved the way to adopting improved surgical techniques, including a selection of intraocular lens (IOL) material and designs.[1] Acrylic IOLs are more resistant to trauma from the YAG laser than silicone IOLs.[4,5] These measures delayed PCO development or reduced the PCO rates (2.7%to 20.4 %).[6,7]

The most commonly performed laser procedure for treating posterior capsular opacification (PCO) is neodymium: yttrium-aluminium-garnet (Nd: YAG) laser capsulotomy. Several patterns of Laser shots-application are used these days. The cruciate pattern (or cross pattern) is one of the frequently employed techniques as it is considered easy to master. The circular pattern (or can-opener method) is another widely employed technique. This technique offers the advantage that it does not cause IOL pits or cracks in the visual axis. However, it involves a free-floating posterior capsular residue disadvantage that can lead to floaters.[8]

An inverted U pattern was introduced to address the problems associated with the two previous techniques. This method does not require the application of laser shots in the central optical zone, so the chance of optic damage is low. Furthermore, since the circular capsular cutout stays at the bottom like a hinge, this capsular flap being still attached is less likely to cause a floater. However, this procedure poses another

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Received: 02 Jan 2020; revision received: 25 Jun 2020; accepted: 30 Jun 2020

problem; since there is some time required for the resulting capsular hinge to sink in the intra-vitreal space due to gravitational pull and capsular contraction, hence immediate visual recovery cannot be assessed. A new technique involving additional shots to cut off vitreous strands adherent to capsular fragments after circular pattern posterior capsulotomy overcomes issues associated with older techniques.[9,10]

The study aimed to compare the efficacy and safety of the three techniques of Nd: YAG posterior capsulotomy namely hinged pattern, conventional circular capsulotomy and modified circular capsulotomy along with vitreous strand cutting in management of posterior capsular opacification.

METHODOLOGY

This Quasi-experimental study was carried out at the Combined Military Hospital Nowshera from August 2015 to March 2017. The Institutional Ethics Review Board approved the study (ltr no 11 dated 21 Oct 2019). The required sample size for this study was calculated by WHO calculator for a two-tailed hypothesis with the power of study 80%, confidence level 95%, effect size of 0.711, and pooled standard deviation of 1.3.[11] The calculated sample size was 120. The patients fulfilling inclusion and exclusion criteria were recruited into the study by non-probability consecutive sampling technique.

Inclusion Criteria: All the patients of either gender, between the age of 45-60 years who had uncomplicated phacoemulsification previously, with no previous history of ocular trauma or other ocular surgery, were included in the study.

Exclusion Criteria: Patients who were operated for complicated cataract secondary to uveitis, pathological myopia, lattice degeneration with associated holes, a history of rhegmatogenous retinal detachment, primary open-angle glaucoma, media opacities other than PCO, cataract surgery less than one year ago and those who had complications like capsule tear, IOL distortion or subluxation were excluded from the study.

Informed written consent was obtained from the patients. A concise history was taken, including past medical history and pre-disposing conditions. A detailed ocular examination was performed, including visual acuity assessment, slit-lamp biomicroscopy, dilated fundus examination, and intraocular pressure assessment. The patients were randomly allocated to three groups (40 patients in each group). Group-A (CG) patients were subjected to circular pattern capsulotomy, group-B (HG); patients underwent hinged pattern capsulotomy and group- C (MG) patients had circular pattern capsulotomy with vitreous strand cutting (modified round pattern).

After dilating the pupil using multiple drops of 1% Tropicamide for around half an hour before laser treatment, the same surgeon performed capsulotomies using a capsulotomy contact lens (12-mm Abraham capsulotomy lens, Ocular Instruments Inc.) in all the cases.[12] After instilling two drops of Proparacaine 0.5% into the conjunctival sac for topical anaesthesia, a single pulse mode Nd: YAG laser was utilized at the minimum effective energy level. The maximum energy used for this procedure was 1.9 mj. Multiple perforations were made in the posterior capsule depending on the pattern of capsulotomy required. One drop of 0.5% Timolol eye drop was instilled both pre-procedure and post-capsulotomy. All the patients were prescribed Dexamethasone drops three times daily following the laser session for seven days. Patients were re-examined at two weeks and at three months post capsulotomy. Best-corrected visual acuity and intraocular pressure were measured on these follow-up visits. A pre-devised proforma was used to document all the relevant details.

Statistical Package for Social Sciences (SPSS) version 23 was used for the data. Descriptive statistics of continuous data were presented as mean and standard deviation, and categorical data were presented as frequency and percentage. Keeping in mind the nature and normality of data, one-way ANOVA was used to detect significant differences among three treatment groups, while repeated measures ANOVA test was used to compare the outcome among treatment groups at three different time points. In order to compare the categorical variables, a chi-square test was used to find any significant associations. The *p*-value of ≤0.05 was considered statistically significant.

RESULTS

Out of 120 patients who were initially included in the study, 117 completed the follow-up protocol, the remaining three patients who could not report for the second follow-up visit were contacted on the phone and inquired about the presence of floaters. The mean age of patients was 52.27 ± 5.65 years with the range of 40–65 years. There were 64 (53.3%) males and 56 (46.7%) females in the study population. One hundred and twenty patients were randomly assigned to either of the three treatment groups, i.e. modified technique, circular and hinged technique for capsulotomy.

Baseline characteristics were similar for each treatment group, as shown in the Table-I.

Visual acuity and intraocular pressure were assessed for each patient before the capsulotomy procedure, followed by two weeks post-operatively and finally assessed again at three-month follow-up period. Group comparisons by one-way ANOVA test showed no statistically significant difference in both the parameters pre-operatively and three treatment groups (p= 0.853), as shown in the Table-I.

Table-I: Preoperative comparison among treatment groups.

Parameters	Treatment Groups			*p*-value
	Circular (n=40)	Hinged (n=40)	Modified (n=40)	
Age in years (Mean ± SD)	52.55 ± 4.89	52.20 ± 5.77	52.05 ± 6.32	0.922*
Gender n (%)				
Male Female	21 (52.5%) 19 (47.5%)	21 (52.5%) 19 (47.5%)	22 (55.0%) 18 (45.0%)	0.967**
Visual Acuity				
Mean ± SD	0.65 ± 0.23	0.65 ± 0.24	0.63 ± 0.22	0.853*
Intraocular Pressure mm HG				
Mean ± SD	13.02 ± 2.83	14.25 ± 2.68	13.75 ± 2.59	0.131*

**One-way ANOVA, **Chi-square*

Similarly, it was observed that all the treatment groups had similar mean best-corrected visual acuity values at three months follow up (p=0.231), whereas post-op visual acuity values at two weeks significantly differed among the treatment groups (p<0.0001). Post hoc Bonferroni test revealed a significant difference in mean visual acuity value between modified vs hinged (p=0.001) and modified vs circular (p=0.001) treatment groups. In contrast, no significant differences were observed between the circular and hinged treatment group (p=0.103), as shown in the Table-II.

Table-II: Comparison of pre and post-operative visual acuity among treatment groups.

Parameters	Treatment Groups			*p*-value
	Circular (n=40)	Hinged (n=40)	Modified (n=40)	
Pre-op Visual Acuity, mm HG	0.65 ± 0.23	0.66 ± 0.23	0.63 ± 0.22	0.853
Post-op Visual Acuity at 2 weeks, mm HG	0.31 ± 0.15	0.38 ± 0.16	0.18 ± 0.13	<0.001
Post-op Visual Acuity at 3 months, mm HG	0.30 ± 0.16	0.37 ± 0.15	0.18 ± 0.12	0.231

One-way ANOVA

Intraocular pressure remained unchanged among modified, circular and hinged groups pre-operatively and post-operatively at two weeks and three months, as shown in the Table-III.

Table-III: Comparison of pre and post-operative intraocular pressure among treatment groups.

Parameters	Treatment Groups			*p*-value
	Circular (n=40)	Hinged (n=40)	Modified (n=40)	
Pre-op Intraocular Pressure, mm HG	13.02 ± 2.83	14.25 ± 2.68	13.75 ± 2.59	0.131
Post-op Intraocular Pressure at 2 weeks, mm HG	16.45 ± 2.37	17.7 ± 2.06	16.80 ± 3.09	0.081
Post-op Intraocular Pressure at 3 months, mm HG	12.70 ± 2.38	13.05 ± 1.66	13.32 ± 2.69	0.475

One-way ANOVA

Patients were also assessed for the visual presentation of any floaters after capsulotomy procedure and group comparison showed that significantly fewer patients in the modified treatment group experienced the presence of annoying floaters in vision after capsulotomy as compared to hinged and circular treatment groups [3 (7.5%) vs 9 (22.5%) vs 12 (30%) respectively, as shown in the Figure.

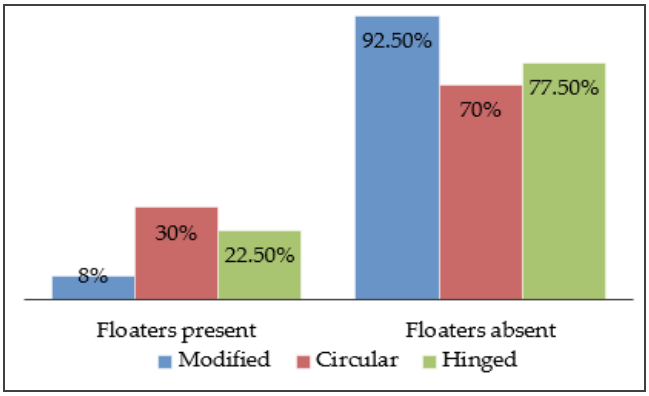

Figure: Presence of annoying floaters post capsulotomy among treatment group.

DISCUSSION

Posterior capsular opacification (PCO) is among the commonest post-cataract surgery complications. Nd: YAG capsulotomy is the conventional method used to treat PCO. Nd: YAG laser has a wavelength of 1064 nm. This laser disrupts ocular tissues by creating a short, high-power pulse resulting in an optical breakdown. Optical breakdown leads to ionization or plasma formation generating acoustic and shock wa-

ves, causing tissues disruption. The laser settings are dependent upon the density of the PCO and vary from 2-6 mj per spot. Typically, 10-30 laser shots are required. Nd: YAG laser posterior capsulotomy has been proven effective in reversing the decreased visual acuity after PCO formation.[12] Similarly, studies have documented improvements in contrast sensitivity and glare.[13] However, the procedure is associated with complications such as intraocular lens (IOL) pitting or subluxation, a transient spike of intraocular pressure (IOP), corneal edema, and cystoid macular oedema raised risk of retinal detachment and delayed post-op endophthalmitis.[11]

Parajuli *et al*, concluded from their study that best -corrected visual acuity (BCVA) improves significantly after Nd: YAG laser posterior capsulotomy.[14] Similarly, many other researchers, including Khambhiphant *et al*, and Oztas *et al*, documented an improvement of the best-corrected visual acuity following Nd: YAG laser posterior capsulotomy.[15-16] Our study also showed a marked improvement in the visual acuity in all the groups. However, post-op visual acuity values at two weeks significantly differed among the treatment groups, with patients in the modified pattern group experiencing better visual acuity compared to the other two groups (p<0.001). However, no significant difference was observed between the circular and hinged treatment groups.

Kara *et al*, demonstrated that the round pattern capsulotomy required more laser shots and hence higher energy consumption than cruciate pattern.[17] It is also foreseeable that the modified round pattern capsulotomy, which involves additional vitreous strands cutting, require even more shots and an even more significant amount of energy. This excess energy consumption is associated with a higher risk of complications, such as an increased incidence of raised IOP.

Previous studies had reported increased incidence rate (0.5-3.6%) of retinal detachment after Nd: YAG capsulotomy.1 A study conducted by Wesolosky *et al*, also demonstrated that there was an increased risk for RD in the first five months after Nd: YAG capsulotomy. The rate of retinal tears after Nd: YAG capsulotomy at five months was 0.29%, whereas the rate of RD was 0.87%.[18] However, Min *et al*, reported no case of retinal detachment in their study of 77 eyes.[1] Similarly, no patient in our study developed this complication after the laser capsulotomy during the follow-up period. Keeping in mind the possible risk of retinal detachment, we ensured to rule out antecedent predisposing factors such as high myopia and lattice degeneration with associated holes, prior to the procedure and minimized the amount of laser energy utilized in the procedure. Moreover, post-procedure, we also ensured to follow up the patients to rule out the possibility of any retinal complications through dilated fundus examination on the following second week and third month.

Many studies have indicated a significant rise of IOP after Nd; YAG capsulotomy.[14,19] In our study, Timolol maleate eye drops were instilled immediately after the procedure and prescribed for outdoor use according to the schedule to prevent the IOP spike following laser capsulotomy. Hence, in our study, intraocular pressure remained unchanged among modified, circular and hinged groups pre-operatively and post-operatively at two weeks and three months.

This relatively new method (modified round pattern capsulotomy with vitreous strand cutting) could potentially address the issues associated with the conventional procedures without posing a significant risk of complications. Removal of vitreous strands attached to fragment during laser capsulotomy results in its quick sinking in the vitreous cavity. This pattern can prevent any optical damage along the visual axis of IOL and create an adequate sized capsulotomy to reverse contrast sensitivity and glare issues.[20,21] It is also proven to be beneficial in preventing vitreous floater by hindering the creation of a free-floating remnant around a visual axis. It is also expected that cutting the vitreous strand tethered to the posterior capsule would overcome additional issues like retinal detachment due to vitreous traction and CME. However, the minimum additional energy required to dissect the vitreous strands and its potential implications is a point of concern in our study. Ventional round pattern and inverted U or hinged pattern simultaneously.

To conclude, modified round pattern Nd: YAG laser posterior capsulotomy can be performed safely and achieves rapid visual rehabilitation compared to the circular capsulotomy and hinged capsulotomy techniques. Since with this novel methodology, one can immediately assess the visual improvement after the procedure and the possibility of reduced floaters, the modified round pattern method of Nd: YAG laser posterior capsulotomy can be considered an excellent alternative procedure.

LIMITATIONS OF STUDY

Our study had limitations as variables like the type of IOL material; the type and degree of posterior capsular opa-

cification were not considered. Hence, further studies are encouraged on large data sets to determine the statistical significance of our observed findings.

CONCLUSION

Modified round pattern Nd: YAG laser posterior capsulotomy is a safe and effective method for treating posterior.

Conflict of Interest: None.

Authors' Contribution

SP:, SN:, KH:, BA: Direct contribution.

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