• Clinical Research •

Comparison of two Nd:YAG laser posterior capsulotomy: cruciate pattern *vs* circular pattern with vitreous strand cutting

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Abstract

• AIM: To investigate the effects and safety of neodymium: yttrium-aluminium-garnet (Nd:YAG) laser posterior capsulotomy with vitreous strand cutting

• METHODS: A total of 40 eyes of 37 patients with symptomatic posterior capsular opacity (PCO) were included in this prospective randomized study and were randomly subjected to either cruciate pattern or round pattern Nd:YAG posterior capsulotomy with vitreous strand cutting (modified round pattern). The best corrected visual acuity (BCVA), intraocular pressure (IOP), refractive error, endothelial cell count (ECC), anterior segment parameters, including anterior chamber depth (ACD) and anterior chamber angle (ACA) were measured before and 1mo after the laser posterior capsulotomy.

• RESULTS: In both groups, the BCVA improved significantly (*P*<0.001 for the modified round pattern group, *P*=0.001 for the cruciate pattern group); the IOP and ECC did not significantly change. The ACD significantly decreased (*P*<0.001 for both) and the ACA significantly increased (*P*=0.001 for the modified round pattern group and *P*=0.034 for the cruciate group). The extent of changes in these parameters was not significantly different between the groups.

• CONCLUSION: Modified round pattern Nd:YAG laser posterior capsulotomy is an effective and safe method for the treatment of PCO. This method significantly changes the ACD and ACA, but the change in refraction is not significant. Modified round pattern Nd:YAG laser posterior capsulotomy can be considered a good alternative procedure in patients with symptomatic PCO.

• KEYWORDS: posterior capsulotomy; modified round pattern; vitreous strand cutting; anterior segment parameter

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INTRODUCTION

The most popular method for treating posterior capsular opacity (PCO) is neodymium: yttrium-aluminium-garnet (Nd:YAG) laser capsulotomy. Despite some complications, including damage to the intraocular lens (IOL), cystoid macular edema, an increase in the intraocular pressure (IOP), iris hemorrhage, corneal edema, IOL subluxation, increased risk of retinal detachment, and exacerbation of localized endophthalmitis, it is well-known that Nd:YAG laser posterior capsulotomy effectively reverses the decrease in visual acuity after PCO formation[1]. Improvements in glare and contrast sensitivity are also well-documented[2]. There have been several studies on the changes in the refractive errors and anterior segment parameters after Nd:YAG posterior laser capsulotomy with conflicting results[3-5].

Several techniques have been described for Nd:YAG laser capsulotomy. The most popular is the cruciate pattern (or cross pattern), which is easy to learn and has a short procedure time[6]. However, the procedure can damage the IOL, involving the visual axis and inducing glare due to the posterior capsule remnant[6]. The circular pattern (or can-opener method) is also a widely used technique, which has the advantage that it does not make IOL pits in the visual axis. However, this procedure can lead to a floating posterior capsule remnant that can cause floaters[6].

Recently, Min *et al*[7] introduced a new technique that cuts off vitreous strands attached to a large fragment after circular pattern posterior capsulotomy. In this study, we compared the efficacy and safety of cruciate pattern and this new technique

of Nd:YAG posterior capsulotomy, including changes in the refractive errors and anterior segment parameters.

SUBJECTS AND METHODS

Fifty-two patients with a history of cataract surgery and symptomatic PCO, who visited the Seoul Metropolitan Government-Seoul National University Boramae Medical Center between January and November 2015, were included in this randomized prospective study. Patients aged less than 20y, and those with a history of previous ocular surgery other than an uneventful phacoemulsification with posterior chamber IOL implantation (in-the-bag placement), and coexisting ocular diseases other than PCO were excluded. Patients who failed to complete follow-up examinations 1mo after the laser capsulotomy were also excluded. This study adhered to the Declaration of Helsinki and the protocol was approved by the institutional review board of Seoul Metropolitan Government-Seoul National University Boramae Medical Center (No.176-2015-30). Written informed consent was obtained after a detailed explanation of the procedure and possible benefits and risks.

The patients were randomly subjected to Nd:YAG laser capsulotomy of either the round pattern with vitreous strand cutting (modified round pattern) or the cruciate pattern. The demographic data, material and position of IOL, and ocular examinations results, including measurements of best corrected visual acuity (BCVA) at a distance using a logarithm of the minimum angle of resolution (logMAR) scale, refractive status using an autorefractometer (KR-8100; Topcon corporation, Tokyo, Japan), IOP measured by pneumatic tonometer (CT-80; Topcon corporation, Tokyo, Japan), and fundus evaluation using an indirect ophthalmoscope were obtained. Evaluation of the corneal endothelium was performed *via* specular microscopy (SP-8000; Konan Inc. Hyogo, Japan); the endothelial cell count (ECC) was noted. Anterior chamber depth (ACD) was measured using two methods: the IOLMaster ultrasound biomicroscope (Carl Zeiss Meditec AG, Jena, Germany) and 35-MHz ultrasound biomicroscopy (UBM, HiScan, Optikon Co. Ltd., Rome, Italy) ACD. The anterior chamber angle (ACA) was defined as the angle between the posterior surface of the cornea and the anterior surface of the iris at the horizontal plane. The measurements were obtained using the UBM, twice each at the nasal and temporal planes. The average values of four measurements were used to determine the ACA.

All laser posterior capsulotomies were performed by the same surgeon (Han YK) using Nd:YAG laser (Aura PT, Lumenis Ltd., Yokneam, Israel). After dilating the pupil using an eye drop containing 0.5% tropicamide and 0.5% phenylephrine hydrochloride, 0.5% proparacaine hydrochloride was instilled for topical anesthesia. A 12-mm Abraham capsulotomy lens (Ocular Instruments Inc., Washington, USA), a contact capsulotomy lens, was used for the capsulotomy with 2% hypromellose gel as the coupling agent. Single pulse mode Nd:YAG laser was used with the minimal power necessary to obtain breakdown of the posterior capsule or the vitreous strands.

In the cruciate pattern group, Nd:YAG laser posterior capsulotomy was fashioned in a cross pattern to create at least a 4-mm diameter opening. In the modified round pattern group, Nd:YAG laser posterior capsulotomy was performed according to the method described by Min *et al*[7]. In brief, the laser was aimed 150 μm posterior to the posterior IOL surface and the capsulotomy was performed following an imaginary circle that was 0.5 mm inside the optic margin or along the anterior continuous curvilinear capsulorhexis. After circular application of the laser, the vitreous strands that were attached to the posterior capsule fragment were cut with the laser[7]. The amount of total energy and the number of shots were recorded. Subsequently, 0.5% apraclonidine hydrochloride, which was reported to have no significant effect on the ACD, pupil size, and refraction, was instilled to prevent elevation of IOP after the laser[8]. The post-capsulotomy IOP was measured using a Goldmann applanation tonometer 1h after the laser procedure. Topical 1% prednisolone acetate was prescribed to all patients four times a day for 1wk.

After examination for possible complications 1wk after the laser posterior capsulotomy, a protocol-based masked examination was conducted 1mo after the laser posterior capsulotomy. The examination included measurements of uncorrected visual acuity and BCVA, refractive status, IOP, ECC, ACD, and ACA. The difference in the outcomes before and after the laser posterior capsulotomy was assessed in addition to the safety measures.

The Student's *t*-test, Chi-square test, and Fisher's exact test were used to compare the patient characteristics and outcomes. A P value of <0.05 was considered statistically significant. All analyses were performed with the SPSS software for Windows (version 21.0; SPSS Inc., Chicago, Illinois, USA).

RESULTS

A total of 55 eyes of 52 patients were initially recruited in the study and randomly distributed to either group. After excluding 14 patients who were lost to follow-up and 1 patient who developed choroidal neovascularization, a total of 40 eyes of 37 patients were included in the final analysis. The mean age, sex, and mean interval between the cataract surgery and Nd:YAG laser posterior capsulotomy were comparable between the two groups. The modified round pattern group required significantly higher total energy and number of shots than the cruciate pattern group (Table 1).

The BCVA significantly improved in both the groups ($P<0.001$ for the modified round pattern group and $P=0.001$ for the cruciate pattern group, paired *t*-test); however, the change in

Table 1 Demographics

Variables	Cruciate pattern	Modified round pattern	*P*
No. of eyes	21	19	
Mean age at procedure (y)	68.1±12.3	67.7±10.9	0.902[a]
Sex (M/F)	8/13	3/16	0.115[b]
Mean interval between cataract operation and posterior capsulotomy (mo)	31.4±29.5	40.8±27.7	0.306[a]
Total energy (mJ)	72.12±28.65	195.88±120.06	<0.001[a]
Total shot number	38.9±13.7	97.5±55.2	<0.001[a]
Change in BCVA (logMAR)	-0.11±0.13	-0.20±0.20	0.111[a]
Change in ACD (mm)			
IOLMaster	-0.79±0.75	-0.91±0.35	0.533[a]
UBM	0.02±0.08	0.03±0.08	0.950[a]
Change in SE (diopters)	-0.14±0.85	0.27±0.73	0.110[a]
Change in ACA (degrees)	1.51±3.05	2.48±2.71	0.296[a]
Change in ECC (cells/mm^2)	-69.9±201.3	-45.0±269.3	0.740[a]
Change in IOP (mm Hg)	-0.8±2.0	-0.3±2.3	0.421[a]

[a]Student's *t*-test; [b]Chi-square test. BCVA: Best corrected visual acuity; logMAR: Logarithm of the minimum angle of resolution; ACD: Anterior chamber depth; UBM: Ultrasound biomicroscopy; SE: Spherical equivalence; ACA: Anterior chamber angle; ECC: Endothelial cell count; IOP: Intraocular pressure.

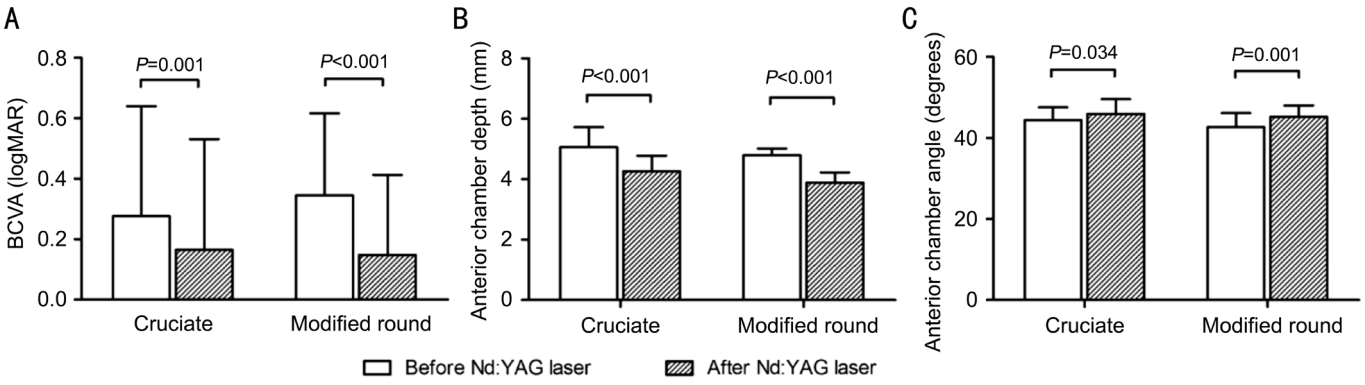

Figure 1 Main outcomes before and after Nd:YAG laser posterior capsulotomy A: BCVA in logMAR scale significantly improved in both the groups (*P*=0.001 for the cruciate pattern group, *P*<0.001 for the modified round pattern group, paired *t*-test); B: The ACD measured by IOLMaster significantly decreased in both the groups (*P*<0.001 for the both group, paired *t*-test); C: The anterior chamber angle significantly increased in both the groups (*P*=0.034 for the cruciate pattern group, *P*=0.001 for the modified round pattern group, paired *t*-test). The amount of changes in these parameters were not significantly different between the two groups. BCVA: Best corrected visual acuity.

BCVA was not significantly different between the two groups (*P*=0.111, Figure 1A). The IOP measured using pneumatic tonometry and the spherical equivalents did not significantly change in both the groups.

The ACD measured by IOLMaster significantly decreased in both the groups (*P*<0.001 for both, Figure 1B); however, the change in ACD was not significantly different between the two groups (*P*=0.533). The ACD measured with UBM were not significantly different before and after the Nd:YAG laser posterior capsulotomy in both the groups (*P*=0.162 for the modified round pattern group and *P*=0.150 for the cruciate pattern group, paired *t*-test). The ACA showed a significant increase in both the groups (*P*=0.001 for the modified round pattern group and *P*=0.034 for the cruciate group, Figure 1C); however, the change in the ACA was also comparable between the two groups (*P*=0.296). The spherical equivalent did not significantly change in both the groups (*P*=0.122 for the modified round pattern group and *P*=0.459 for the cruciate pattern group, paired *t*-test). The IOP and ECC were also not significantly changed in both the groups (*P*=0.617 and 0.476 for modified round pattern group and *P*=0.077 and 0.127 for the cruciate group, respectively).

Of the 27 patients with information on the material of the IOL, 16 had hydrophilic acrylic IOLs and 11 had hydrophobic acrylic IOLs implanted. There was no difference regarding the changes in the BCVA, IOP, ACD, ACA, total energy, and number of shots number required between the group that had hydrophilic IOLs and the one that had hydrophobic IOLs implanted. The mean interval between the cataract surgery and the laser posterior capsulotomy was 29.31±13.96mo for the hydrophilic acrylic IOL group and 55.09±29.24mo for the hydrophobic acrylic IOL group. It was significantly longer

in the group that had hydrophobic acrylic IOLs implanted (P=0.017, Fisher's exact test).

DISCUSSION

In this study, we performed an analysis focused on the effects and safety of new method of Nd:YAG laser posterior capsulotomy that cuts off vitreous strands attached to a large fragment after circular pattern posterior capsulotomy. The new pattern of Nd:YAG laser posterior capsulotomy showed a comparable effect on the recovery of visual acuity and had no significant complications, including increase in IOP, change in spherical equivalent, and decrease in ECC.

An improvement in the visual acuity after Nd:YAG laser posterior capsulotomy has been well-documented[4-6]. We found a significant improvement in the visual acuity in both the groups; however, the improvement was not significantly different between the two groups. This result was predictable since the improvement is dependent on the removal of PCO, regardless of the method used. None of the patients reported glare or floaters.

The modified round pattern Nd:YAG laser posterior capsulotomy required significantly larger amount of energy and a higher number of shots. Previous studies[3,6,9-10] that compared cruciate and round pattern laser posterior capsulotomies consistently reported that the round pattern required a larger amount of energy and higher number of shots. It is sufficiently predictable that the modified round pattern, which needs additional vitreous cutting shots, requires a higher number of shots and larger amount of energy. Since a larger total energy is reported to be associated with more complications, such as an increased incidence of IOP rise and a decrease in the ECC, these complications were a cause of concern in the modified round pattern group[10].

Many studies have reported a rise in the IOP after Nd:YAG laser posterior capsulotomy without the administration of IOP-lowering medications, although the evidence for long-term IOP change is not clear[11]. After administration of IOP-lowering medication, such as 0.5% apraclonidine, most studies did not report an IOP rise after laser capsulotomy. Several studies have reported elevated IOP in relation to the IOL position or overlap of the anterior capsule over the IOL, but little or no increase in patients with in-the-bag IOLs[12]. As our study included patients with in-the-bag IOLs alone, no significant change in IOP was observed and none of the patients showed an increase in the IOP of more than 5 mm Hg 1mo after the laser capsulotomy. In addition, an elevation in the IOP 1h after the laser posterior capsulotomy was not observed in all patients.

Several studies have suggested possible damage to the corneal endothelium due to Nd:YAG posterior capsulotomy, particularly with a large amount of laser energy[13]. An experiment on rabbits reported diminished ECC 6h after the laser posterior capsulotomy[14]. However, we could not find any study that reported a decrease in the ECC after a laser posterior capsulotomy. The most recent study on the association between Nd:YAG laser capsulotomy and ECC did not find any difference in the corneal endothelium between treated and untreated eyes[15]. Since PCO is located behind the IOL, careful laser posterior capsulotomy by an expert may minimize the possible damage to the corneal endothelium. Our study also found no difference in the ECC before and after the laser posterior capsulotomy.

There have been many reports that Nd:YAG laser posterior capsulotomy might alter the anterior segment parameters, such as ACD and ACA. Several studies have reported backward movement of the IOL and hyperopic shift after Nd:YAG posterior capsulotomy[16]. Although many studies did not find significant changes in the ACD and refractive status, several studies have reported significantly decreased ACD after laser posterior capsulotomy[3-5,17-18]. Zaidi and Askari[18] reported that Nd:YAG laser posterior capsulotomy led to a definite and significant decrease in the ACD and thus, a myopic shift. A recent study by Oztas *et al*[5] reported significantly decreased ACD and expended anterior angle as measured by Pentacam, which is known to have excellent reliability and repeatability[19-20]. In this study, both cruciate and modified round pattern groups showed significantly decreased ACD and increased ACA after Nd:YAG posterior capsulotomy, which was consistent with the finding of the study by Oztas *et al*[5]. Since there was no narrowing of the ACA after laser posterior capsulotomy, it might be assumed that a decrease in the ACD was due to the forward movement of the IOL rather than a true flattening of the anterior chamber with the iris plane. Absence of the pull of the vitreous on the IOL could be the possible mechanism for the forward movement of the IOL and further studies are needed to verify this concept. Increase in ACA after laser posterior capsulotomy was reported by Oztas *et al*[5], but it only lasted 1wk and returned to baseline values at one month. The authors mentioned possibility of increase in ACA due to elevated IOP, but IOP was not elevated in both this study and our study. There is no clear explanation for increase in ACA and further studies that observe more detailed structure of the ACA are requied.

The material of the IOL is an important factor in the development of PCO[21]. It is well-recognized that hydrophilic acrylic material is more prone to support adhesion, migration, and proliferation of the lens epithelial cells, which leads to the development of PCO[22-24]. Our study also showed that the hydrophobic acrylic IOL group required significantly longer time to develop symptomatic PCO. We also performed an analysis on the possible association between the material of the IOL and the incidence of complications or changes in anterior segment parameters; no significant differences were found between the hydrophilic acrylic IOL group and the hydrophobic acrylic IOL group.

Our study was the first prospective, randomized study to compare the effects and safety of the modified round pattern Nd:YAG laser posterior capsulotomy with the classic cruciate pattern, including changes in the anterior segment parameters. This study also has a few limitations. First, the sample size in this study was relatively small. Second, the type and degree of PCO was not considered as a variable. Further studies on moderate to severe PCO may find statistically significant differences in the complication rates.

In conclusion, this new method of Nd:YAG laser posterior capsulotomy was effective and safe for treating PCO after cataract surgery, compared to the classical cruciate pattern capsulotomy. The modified round pattern Nd:YAG laser posterior capsulotomy could alter the anterior segment parameters by flattening the anterior chamber and increasing the ACA; however, the parameters were comparable with those of the cruciate pattern method and did not result in a significant change in the refractive error. Since with the new method, one can immediately check the visual improvement after the procedure and reduce the possibility of floaters[7], the modified round pattern method of Nd:YAG laser posterior capsulotomy can be considered as a good alternative procedure.

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