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ORIGINAL ARTICLE

The impact of Nd: YAG laser posterior capsulotomy by the use of "the circular pattern with vitreous strand cut" technique on anterior chamber parameters

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Abstract

Aim The purpose of this study is to identify the effect of Nd: YAG laser posterior capsulotomy using an anterior chamber morphology.

Methods This study included 42 eyes of 33 pseudophakic patients with visually significant PCO after uncomplicated cataract surgery. Exclusion criteria were complications related to cataract surgery, corneal pathology, pseudoexfoliation, glaucoma, uveitis, previous ocular surgery or trauma, and posterior segment pathology. All patients underwent routine ophthalmic examinations. The AS-OCT measurements were performed using NIDEK RS-3000 Lite retinal scan with anterior segment module. The anterior chamber depth (ACD) was measured by Monitor A&B Scan biometer. Nd: YAG laser posterior capsulotomy was done in a single session by the circular pattern with rupture of vitreous strands. Anterior chamber depth (ACD), central corneal thickness (CCT), and intraocular pressure (IOP) were measured. Anterior chamber angle (ACA), angle opening distances (AOD) at 500 mm (AOD500), AOD at 750 mm (AOD750), trabecular-iris space area at 500 (TISA 500), and TISA at 750 (TISA 750) were measured both nasally and temporally.

Results The mean patient age was 55.56 ± 6.33 years. There were non-significant changes in IOP, ACD, and CCT with *P* values 0.395, 0.153, and 0.541, respectively. ACA, AOD500, AOD750, TISA 500, and TISA 750 highly significantly increased with *P* value < 0.001 for all.

Conclusion Nd: YAG laser posterior capsulotomy with the circular pattern with vitreous strand cut technique is a safe technique for laser posterior capsulotomy.

Keywords Nd: YAG laser · Posterior capsulotomy · Circular pattern · Vitreous strand cut technique

Introduction

Posterior capsular opacification is the most common complication that occurs after cataract surgery [1, 2]. It develops as a consequence of the proliferation of remaining epithelial cells and their migration to the space between the intraocular lens (IOL) and the posterior capsule. Also, debris of some inflammatory cells or proteins, mechanical wrinkles of the capsular bag, and trapped lens remnants may play roles in the formation of PCO [3, 4].

Neodymium-doped yttrium aluminum garnet (Nd: YAG) laser capsulotomy (which was first described in 1980) is an effective technique and is so-called the gold standard for treating visually significant PCO in pseudophakic eyes [3–6].

Several patterns can be used in laser application. One of the commonly used techniques is "cross pattern technique," which is easy to learn and needs comparatively less time. But, its side effects include cracks and pit marks along the visual axis at an IOL optics since the laser is applied in axial region and that can cause forward light scattering from capsule remnants and glare symptoms [7]. "Can opener technique" is another conventional method in which a circular application of laser is applied along the optic circumference. This method has the advantage of preventing the IOL damage, but involves a drawback that the

Precis There was no study investigated the effect of this technique (circular pattern with vitreous strand cut technique) of YAG laser posterior capsulotomy on anterior chamber morphology. This technique is safe with avoidance of visual axis.

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large free-floating remnant can hide visual axis. The weaknesses of the previous two methods were opposed by the inverted U method, but another problem appeared; delayed vision recovery can occur as some time is required until the sink of resultant flap in intravitreal space by gravity and contraction of the capsule [8]. First crack-guided conservative posterior capsulotomy is a technique done by Shah et al. [9].

In this study, the circular pattern with vitreous strand cut method was used. This method has been firstly done by Min et al. [7] to overcome the problems associated with conventional methods.

The aim of this study is to investigate changes in anterior chamber parameters after using this technique (the circular pattern with vitreous strand cut technique) in Nd: YAG laser posterior capsulotomy. This technique requires more laser applications; this may affect the final visual acuity of patients by changing the anterior chamber parameters. If these changes are similar to the cross pattern technique, this technique (the circular pattern with vitreous strand cut technique) will have the advantage of being away from the visual axis.

Patients and method

This study included 42 eyes of 33 pseudophakic patients (19 male and 23 female) with visually significant PCO after uncomplicated cataract surgery and in the bag implantation of the haptic intraocular lens. Informed consent was obtained from each patient before the study.

Exclusion criteria were complications related to cataract surgery, corneal pathology, pseudoexfoliation, glaucoma, uveitis, previous ocular surgery or trauma, and posterior segment pathology.

All patients underwent routine ophthalmic examinations, including visual acuity, slit-lamp biomicroscopy, Goldmann tonometry, and fundoscopy before and 1 week after Nd: YAG laser capsulotomy.

The AS-OCT measurements were performed before and 1 week after the Nd: YAG laser capsulotomy using a NIDEK RS-3000 retinal scan with anterior segment module. For the measurements, pupils were undilated, and patients were asked to sit and fixate on to AS-OCT. Images of the temporal and nasal angle quadrants (180° and 0°meridians) were captured using anterior chamber angle (ACA) line until the centration and quality were sufficient for analysis. Also, the cornea radial scan pattern was used to measure the central corneal thickness (CCT) (Fig. 1). The best images were selected and analyzed to detect changes by Nd: YAG laser capsulotomy over anterior chamber angle (ACA) and central corneal thickness (CCT).

ACA width was calculated by measuring the angle between the posterior corneal surface and the iris tangential line with its apex in the angle recess. After manual identification of the apex of the iris recess and scleral spur, anterior chamber angle width was analyzed using standardized angle parameters. Angle opening distances (AOD) at 750 mm (AOD750) and AOD at 500 mm (AOD500) were measured as the perpendicular distances measured from the trabecular meshwork at 750 and 500 mm, respectively, anterior to the scleral spur to the anterior iris surface. Trabecular-iris space area (TISA): trapezoidal area (TISA 750 or 500) bounded by the AOD 750 or 500, the anterior iris surface, the inner corneo-scleral wall, and the perpendicular distance between the scleral spur and the opposing iris (Fig. 2).

The anterior chamber depth (ACD) was measured by Monitor A&B Scan biometer. After corneal anesthesia, the biometer probe was placed vertically at the center of the cornea. The anterior chamber depth was determined by calculating the mean of five consecutive measurements.

Nd: YAG laser posterior capsulotomy was done in a single session by the circular pattern with rupture of the vitreous strands described by Min et al. [7]. Zeiss VISULAS YAG III Laser System (Carl Zeiss Meditec, Germany) was used for making the capsulotomy. Abraham contact lens with a coupling agent was applied to the eye to improve focusing of the laser beam after applying topical anesthesia. The circular pattern posterior capsulotomy was done in a size of 4–4.5 mm by a power ranging from 0.9 to 1.8 MJ/pulse. After circular application of the laser, the vitreous strands which were attached with a fragment were cut with the laser. Thus, a complete separation of the circular fragment from vitreous occurs and then sinks quickly in intravitreal space. Timolol maleate eye drop was given twice daily for 3 days, and fluorometholone eye drop was given four times daily for a week.

The character of used laser

The used laser was Nd: YAG laser. Nd: YAG lasers typically emit light with a wavelength of 1064 nm, in the infrared. Pulsed Nd: YAG lasers are typically operated in the Q-switching mode. In this Q-switched mode, output powers of 250 MW and pulse durations of 10 to 25 ns have been achieved. The posterior focus shift was used in which the therapy beam is posteriorly shifted from the aiming beam by150 μm. The pulse length is typically 2 ns to 3 ns. The single pulse mode was used with maximum pulse repetition rate of 2.5 Hz (5 shots/2 s). The focus diameter is 10 μm in the air.

All the data were collected before and 1 week after Nd: YAG laser capsulotomy and were analyzed statically. Using a paired *t* test, the pre-operative and post-operative IOP, CCT, ACD, and angle measurements were compared. *P*-values were considered statistically significant when < 0.05.

Results

The mean patient age was 55.56 ± 6.33 years. The duration between cataract surgery and Nd: YAG laser capsulotomy

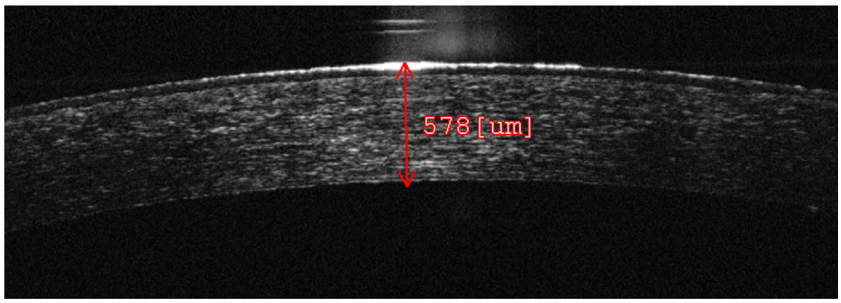

Fig. 1 Central corneal thickness (CCT) measured by AS-OCT

ranged from 6 to 36 months. The best corrected visual acuity (BCVA) was significantly improved [(0.20 ± 0.06) and (0.85 ± 0.05) before and after capsulotomy]. The mean intraocular pressure (IOP) was 14.96 ± 1.63 mm Hg before capsulotomy and 14.92 ± 1.72 mm Hg 1 week after capsulotomy with p value = 0.395. There was a non-significant change in ACD with mean ACD values before and 1 week after capsulotomy 3.61 ± 0.33 mm and 3.71 ± 0.42 mm respectively with p value = 0.153. There was a non-significant change in CCT with mean CCT before and 1 week after capsulotomy 534.31 ± 40.10 μm and 536.31 ± 45.51 μm respectively with p value = 0.541 (Table 1).

There were highly significant increase in all temporal and nasal angle parameters (nasal ACA, nasal AOD 500, nasal AOD 750, nasal TISA 500, nasal TISA 750, temporal ACA, temporal AOD 500, temporal AOD 750, temporal TISA 500, and temporal TISA750) with $p < 0.001$ (Table 2).

Discussion

No studies were found in the computerized search on the effect of this method of posterior capsulotomy (the circular pattern with vitreous strand cut) on the anterior chamber parameters. However, several studies have investigated the effect of conventional cross pattern Nd: YAG laser capsulotomy on the anterior chamber.

One of common complications of Nd: YAG laser capsulotomy is the elevation of IOP. In this study, no elevation of IOP could be detected. This has been reported in several studies, including Shani et al. [10], Ozkurt et al. [5], Ari et al. [11], and Simsek [4]. However, Keates et al. [12], Stark et al. [13], Ge et al. [14], and Karahan et al. [15] reported an increase in IOP after Nd: YAG laser posterior capsulotomy.

The ACD may change after YAG posterior capsulotomy. Some studies reported decrease in ACD after Nd: YAG posterior capsulotomy by using different methods in ACD measuring. These studies include Zaidi and Askari [16], Ozats et al. [6], and Simsek [4]. However, Findl et al. [17] and Eliaçık et al. [2] have found an increase in ACD after Nd: YAG laser posterior capsulotomy. In this study, there were non-significant changes in the ACD after Nd: YAG laser posterior capsulotomy with the circular pattern with vitreous strand cut technique. This has matched with Thornval and Naeser [18], Hu et al. [1], and Ozkurt et al. [5]. They all used biometric ultrasound in detecting ADC and did not find significant changes in ACD after Nd: YAG posterior capsulotomy. Pekal et al. [3] used the Scheimpflug imaging system (Pentacam HR) and also found the same result. The decrease in the reported ACD was explained by IOL position change

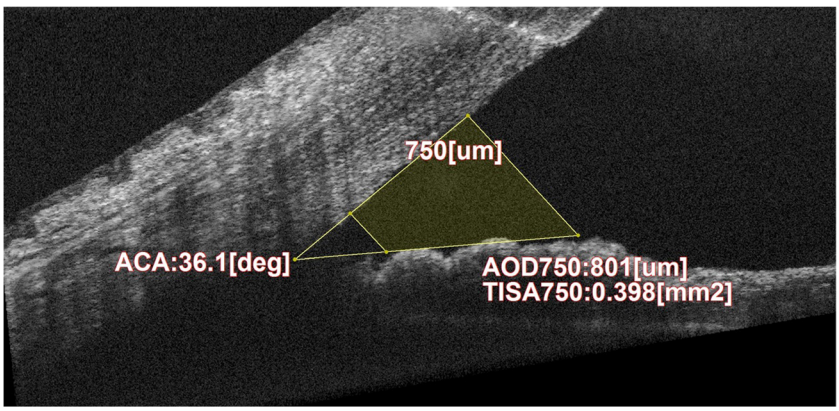

Fig. 2 The angle parameters measured by AS-OCT. Anterior chamber angle (ACA): width was calculated by measuring the angle between the iris tangential line and the posterior corneal surface with its apex in the angle recess; angle opening distance at 750 (AOD 750) was measured as the perpendicular distances measured from the trabecular meshwork at 750 mm anterior to the scleral spur to the anterior iris surface. Trabecular-iris space area (TISA): trapezoidal area (TISA 750) bounded by the AOD 750, the anterior iris surface, the inner corneo-scleral wall, and the perpendicular distance between the scleral spur and the opposing iris

Table 1 Change in intraocular pressure (IOP), central corneal thickness (CCT), and anterior chamber depth (ACD) before and after Nd: YAG laser posterior capsulotomy with the circular pattern with vitreous strand cut technique

		Before No. = 42	After No. = 42	*P* value	Sig.
IOP	Mean ± SD	14.96 ± 1.63	14.92 ± 1.72	0.395	NS
	Range				
CCT	Mean ± SD	534.31 ± 40.10	536.31 ± 45.51	0.541	NS
	Range	483–591	475–598		
ACD	Mean ± SD	3.61 ± 0.33	3.71 ± 0.42	0.153	NS
	Range	3.25–4.4	2.99–4.55		

NS non-significant, *S* significant, *HS* highly significant

Paired *t* test

caused by a posterior push from prolapsed vitreous. While the increase in ACD was explained by the backward movement of the IOL, this movement resulted in the deepening of the anterior chamber.

Changes in CCT have been reported. Wroblewska-Czajka et al. [19] reported that CCT values increased after Nd: YAG laser posterior capsulotomy. Oztas et al. [6] suggested that a statistically significant 10-μm decrease in CCT was detected after Nd: YAG posterior capsulotomy. However, the mechanism for this decrease could not be explained. While the increase in CCT may be explained by the release of inflammatory mediators after the laser capsulotomy, temporary endothelial cell dysfunction due to acoustic waves, possible IOP fluctuations, the topical medications used before the laser capsulotomy, and the coupling gel used during the procedure occur. In this study, non-significant changes can be detected in CCT. This has matched with Ruiz-Casas et al. [20], Pekal et al. [3], and Simsek [4].

The angle parameters may be affected after Nd: YAG posterior capsulotomy. Eliacik et al. [2], who measured ACA after posterior capsulotomy but with the use of the conventional cross pattern technique by AS-OCT, has found increase in ACA measures. Their results matched with mine. However, Pekel et al. [3] found non-significant changes in ACA after Nd: YAG laser posterior capsulotomy but with the use of conventional cross pattern technique and Pentacam HR. This difference in results may be attributed to the difference in the technique used in capsulotomy and the difference in the machine used for the measurements. AS-OCT is more accurate in angle measurement as Pentacam was difficult in visualizing the extremest end of the angle. AOD 500, AOD 750 increased both nasally and temporally. This matches with Eliacik et al. [2].

As regards TISA 500 and TISA 750 in this study, there were significant increases after Nd: YAG laser posterior

Table 2 Change in angle parameters after and before Nd: YAG laser posterior capsulotomy with the circular pattern with vitreous strand cut technique

		Before No. = 42	After No. = 42	Test value	*P* value	Sig.
Nasal angle						
ACA	Mean ± SD	35.45 ± 5.95	36.95 ± 6.09	− 5.333	0.000	HS
	Range	23.6–42.5	24.8–43.7			
N AOD 500	Mean ± SD	601.54 ± 138.94	665.92 ± 147.36	− 5.282	0.000	HS
	Range	413–908	424–989			
N AOD 750	Mean ± SD	843.08 ± 156.46	890.85 ± 160.01	− 6.684	0.000	HS
	Range	502–1058	523–1125			
N TISA 500	Mean ± SD	220.00 ± 44.14	254.38 ± 46.30	− 6.172	0.000	HS
	Range	151–298	182–324			
N TISA 750	Mean ± SD	405.15 ± 88.39	445.08 ± 105.43	− 4.803	0.000	HS
	Range	226–535	236–590			
Temporal angle						
T ACA	Mean ± SD	37.92 ± 3.42	39.80 ± 3.36	− 5.973	0.000	HS
	Range	31.1–42.7	33.4–44			
T AOD 500	Mean ± SD	677.23 ± 106.31	771.85 ± 117.07	− 8.498	0.000	HS
	Range	568–957	626–1027			
T AOD 750	Mean ± SD	831.54 ± 98.76	908.38 ± 124.26	− 6.865	0.000	HS
	Range	698–1023	712–1127			
T TISA 500	Mean ± SD	239.08 ± 62.94	308.62 ± 67.30	− 4.629	0.001	HS
	Range	155–395	230–423			
T TISA 750	Mean ± SD	404.54 ± 67.46	467.15 ± 75.80	− 6.923	0.000	HS
	Range	286–504	365–607			

ACA anterior chamber angle, *N AOD* nasal angle opening distance, *N TISA* nasal trabecular-iris space area, *T AOD* temporal angle opening distance, and *T TISA* temporal trabecular-iris space area

capsulotomy with the circular pattern with vitreous strand cut technique. No reference to this parameter could be found in a computerized search even by the conventional cross pattern technique.

These increases in all angle parameters may be attributed to the mechanical effect of the shock waves associated with the laser on the zonules leading to zonular weakness and shifting of IOL by vitreous cavitation. This hypothesis was strengthened by Eliacik et al. [21] who found an increase in ACA in eyes with pseudoexfoliation (PEX) more than control eyes. As eyes with PEX have weak zonules, they are more liable to laser mechanical effect.

The limitations of this study include a small number of the patients, lack of further correlation with IOL type, and lack of studies on this technique of Nd: YAG laser posterior capsulotomy to compare the results.

In conclusion, Nd: YAG laser posterior capsulotomy with the circular pattern with vitreous strand cut technique is a safe technique. It causes no change in IOP, CCT, and ACD. However, it increases all angle parameters. These increases in angle parameters did not affect the BCVA of the patients.

Compliance with ethical standards

Conflicts of interest The author declares no conflict of interest.

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