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ORIGINAL ARTICLE

Intraocular pressure increase after Nd:YAG laser capsulotomy and anterior segment optical coherence tomography analysis

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Abstract

This study is to determine whether post-procedure intraocular pressure (IOP) increase is associated with the anterior chamber angle in cases of Neodymium: yttrium-aluminum garnet (Nd: YAG) laser capsulotomy. The study included 51 eyes with posterior capsule opacification. Initial IOP values of the patients were compared with IOP values without intraocular pressure-lowering administration at the end of the 1st hour, 1st day, 3rd day, and 7th day after Nd:YAG laser capsulotomy. The anterior segment angle configuration was evaluated using anterior segment optical coherence tomography analysis without dilatation before the procedure. The anterior chamber angle (ACA) and angle opening distances of 500 and 750 µm (AOD500 and AOD750) in the nasal and temporal quadrants were examined. The mean pre-laser IOP value only increased significantly at 1st hour post-laser (13.02 ± 3.02 mmHg vs 14.16 ± 4.07 mmHg, $p = 0.016$). In eyes with ACA below 40° in both the nasal and temporal quadrants, mean IOP increased significantly at 1st hour post-laser ($p = 0.025$ and $p = 0.032$, respectively), while it was not significant in eyes with ACA above 40° ($p > 0.05$). No correlation was found between ACA, AOD500, and AOD750 values and IOP changes at the first hour ($p > 0.05$). Except for the first hour after Nd:YAG laser capsulotomy, no significant increase in IOP was observed. This elevation was higher in eyes with ACA less than 40°. In patients with a narrow ACA, first-hour follow-up may be beneficial in terms of susceptibility to increased IOP.

Keywords Anterior chamber angle · Anterior segment optical coherence tomography · Intraocular pressure · Nd:YAG laser capsulotomy

Introduction

Posterior capsule opacification (PCO) is a common complication of cataract surgery with a frequency of 7–31% after posterior chamber intraocular lens implantation [1]. Neodymium:yttrium-aluminum-garnet (Nd:YAG) laser capsulotomy, first described in 1980, is an effective and non-invasive procedure for PCO [2]. Some of the reported complications after laser capsulotomy include corneal burns, increased intraocular pressure (IOP), intraocular lens pits/cracking/movement, hyphema, uveitis, cystoid macular edema, and retinal detachment [3]. Elevated IOP is a common complication, and anti-glaucoma drugs are frequently prescribed after capsulotomy [4].

The possible mechanisms of an increase in IOP after Nd:YAG capsulotomy have been suggested to be as follows: effects on the ciliary body from laser shock waves, a neurohumoral increase in IOP, pupillary block, iris root changes leading to angle closure, structural effects of laser energy on vitreous sodium hyaluronate, fragmented posterior capsule fragments or vitreous particles floating in the anterior chamber, and ultimately mechanical obstruction caused by various debris in the trabecular meshwork [3–5]. The laser power/count, the presence of glaucoma/aphakia, intraocular lens material/position, and the size of the capsulotomy have been investigated in order to determine the risk factors that cause increased IOP after Nd:YAG capsulotomy [4–12]. To the best of our knowledge, this is the first study to examine the relationship between the anterior chamber angle (ACA) and IOP change after Nd:YAG capsulotomy.

The aim of this study was to evaluate the relationship between IOP increase and anterior segment angle

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configuration in patients who underwent Nd:YAG laser capsulotomy by quantitatively measuring with anterior segment optical coherence tomography (AS-OCT).

Materials and methods

This prospective study was approved by the Local Ethics Committee. The tenets of the Declaration of Helsinki were followed. This study was carried out with patients diagnosed with PCO at an eye clinic of a tertiary-level referral hospital. After a detailed explanation was given, written informed consent was obtained from each patient. The study included 51 eyes that had developed PCO after posterior chamber intraocular lens implantation. All the patients were of Caucasian origin.

Patients with a corneal dystrophy-scar, glaucoma, laser peripheral iridotomy, uveitis, antiglaucomatous drug usage, history of ocular trauma, and ocular surgery other than cataract surgery were excluded from the study. Age, gender, best corrected visual acuity (BCVA) with Snellen chart, and anterior and posterior segment examination findings with slit lamp biomicroscopy were recorded. The IOP measurements of the cases were performed using a Goldmann applanation tonometer. After the eyes of the patients were dilated, the initial IOP values were measured. The initial IOP values of the patients were compared with IOP values at the end of the 1st hour, 1st day, 3rd day, and 7th day after Nd:YAG laser capsulotomy without the use of intraocular pressure lowering medication.

The anterior segment angle configuration of all the patients was evaluated using Spectralis optical coherence tomography (OCT) (Heidelberg Engineering GmbH, Heidelberg, Germany) under the same light conditions when undilated before Nd:YAG laser capsulotomy. Patients were asked to look straight ahead at a fixed target within the device during the imaging procedure. The ACA and angle opening distances of 500 and 750 μm (AOD500 and AOD750) in the nasal and temporal quadrants were examined using the anterior segment lens with image capture software in the mode: angle-to-angle imaging (anterior chamber angle, high speed), single horizontal scan (0° and 180° meridians). The ACA width was calculated by measuring the angle between the iris tangential line and the posterior corneal surface at the apex angle recess. The angle opening distances at 500 μm and 750 μm were measured as perpendicular distances drawn from the trabecular meshwork at 500 μm and 750 μm, anterior to the scleral spur to the anterior iris surface (Fig.1).

Thirty minutes before Nd:YAG laser capsulotomy, 0.5% tropicamide was instilled into all eyes for pupil dilation. After topical application of 0.5% proparacaine hydrochloride, the energy power of the Nd:YAG laser device (Optimis Fusion, Quantel Medical, France) was adjusted according to the PCO density. After the Abraham capsulotomy lens was placed in the eyes, a 4-mm-wide capsulotomy was opened in the optic axis area in the form of a plus sign (+) in a single session by the same surgeon (S.K.K.). After the procedure, 0.4% ketorolac drops were prescribed four times a day for 1 week.

Statistical analysis

The statistical data of the study were analyzed using SPSS vn. 22.0 software (SPSS, Chicago, IL, USA). Descriptive data were given as mean ± standard deviation values. Visual (histogram and probability graphs) and analytical methods (Kolmogorov-Smirnov test) were performed for all data samples to check the normality of distribution. The Chi-square test was used in the analysis of categorical variables. A paired samples *t*-test was applied to compare the values of the cases before and after laser capsulotomy. Correlations were assessed with Pearson correlation analysis. The Independent Samples *t* test was used to compare two independent groups. A value of $p < 0.05$ was accepted as the level of statistical significance.

Results

We enrolled 51 eyes (27 right, 24 left) with posterior capsule opacification of 51 pseudophakic patients, comprising 29 males and 22 females with a mean age of 63.75 ± 11.62 years (range, 35–83 years). The average number of laser shots was 12.90 ± 6.66 shots, the average laser power per

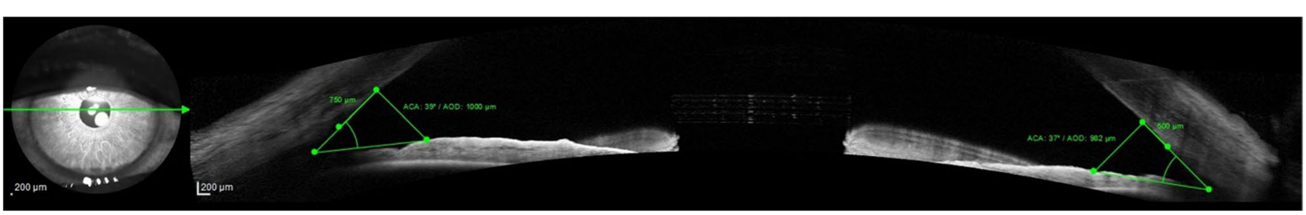

Fig. 1 Anterior segment optical coherence tomography image of a patient with posterior capsule opacification in the right eye, showing the anterior chamber angle and the angle opening distance of 750 μm in the temporal quadrant, and anterior chamber angle and the angle opening distance of 500 μm in the nasal quadrant

shot was 3.55 ± 0.97 mJ, and total laser power applied was 45.10 ± 26.01 mJ.

The mean pre-laser IOP value was 13.02 ± 3.02 (range, 8–23) mmHg. The mean IOP values were 14.16 ± 4.07 (range, 7–24) mmHg at the 1st hour after laser, 13.71 ± 3.14 (range, 8–22) mmHg on the 1st day after laser, 13.41 ± 2.77 (range, 7–22) mmHg on the 3rd day after laser, and 13.31 ± 2.89 (range, 8–22) mmHg on the 7th day after laser (Fig. 2). The mean pre-laser IOP value increased significantly at the 1st hour post-laser ($p = 0.016$). There were no statically significant changes between mean IOP before the laser and on the 1st, 3rd, and 7th days after the procedure ($p > 0.05$). The number of cases with IOP elevation of 5 mmHg or more was 7 (13.7%) at the 1st hour. In one patient (2%), IOP increased by 10 mmHg at the 1st hour. There were 2 patients (3.9%) with IOP elevation of 5 mmHg at the 7th day after the procedure. The ACA values of these two cases were below 40° in both the nasal and temporal quadrants. These two cases were found to return to normal IOP values at the 2nd week of follow-up.

The average number of laser shots, average laser power per shot, and total laser power applied to eyes below and above ACA 40° in both the nasal and temporal quadrants were similar ($p > 0.05$). The mean IOP increased significantly at the 1st hour after laser in the group with ACA below 40° in both the nasal and temporal quadrants ($p = 0.025$ and $p = 0.032$, respectively) and was not significant in the group with ACA above 40° ($p > 0.05$, Tables 1 and 2). No significant correlation was observed between nasal and temporal quadrant ACA, AOD500, and AOD750 values and IOP change at the first hour ($p > 0.05$). No correlation was found between the number of laser spots, laser power per pulse, and the total laser energy power and IOP change at the first hour ($p > 0.05$).

Discussion

Gonioscopy, ultrasound biomicroscopy, and AS-OCT are commonly used to evaluate the anterior chamber angle [13–15]. Anterior segment OCT analysis is a reliable and non-contact method to quantitatively measure anterior segment angle configuration [13–16]. The positive aspects of AS-OCT are that it provides patient comfort with its non-contact structure, it is a light-based system that provides high-resolution images quickly, and it allows fast image acquisition in the sitting position without the risk of mechanical distortion in the angle [13–15]. Findings in previous studies have shown that AS-OCT is more reliable than ultrasound in measuring angle measurements [13, 17]. In the current study, the relationship was analyzed between anterior segment configuration using AS-OCT and changes in IOP after Nd:YAG laser capsulotomy.

According to Shetty et al. [8], only patients who require more than 40 shots during the procedure need close observation, and if sustained elevation is observed,

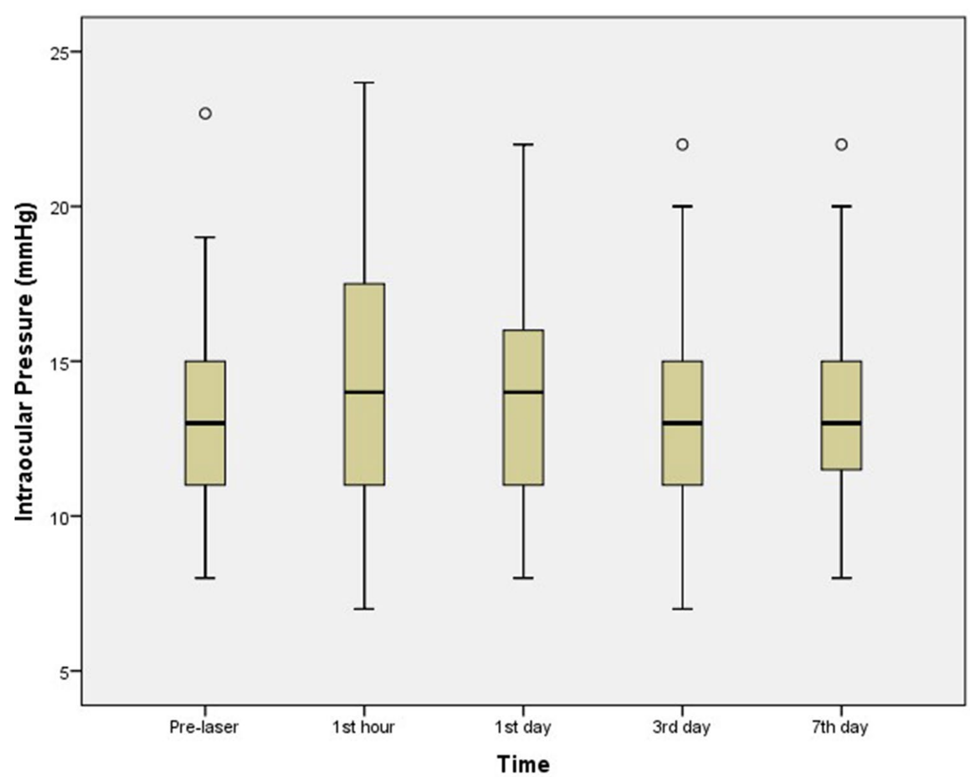

Fig. 2 The mean intraocular pressure values of the patients before and after the laser at the 1st hour, 1st day, 3rd day, and 7th day

Table 1 Clinical characteristics and measurements of eyes with anterior chamber angle above and below 40° in the nasal quadrant

Characteristic	Below 40° ($n = 28$)	Above 40° ($n = 23$)	p Value
Age, years	62.36 ± 11.95	65.43 ± 11.22	0.352
Pre-laser IOP, mmHg	12.79 ± 2.67	13.30 ± 3.44	0.547
Nasal AOD500, µm	701.32 ± 108.12	892.96 ± 157.85	**< 0.001**
Nasal AOD750, µm	843.64 ± 117.88	1034.26 ± 164.61	**< 0.001**
Nasal ACA, °	35.59 ± 3.10	44.02 ± 3.50	**< 0.001**
Temporal AOD500, µm	683.43 ± 114.35	867.87 ± 165.50	**< 0.001**
Temporal AOD750, µm	821.18 ± 143.27	1014.26 ± 158.87	**< 0.001**
Temporal ACA, °	35.09 ± 3.63	42.76 ± 3.52	**< 0.001**
Counts of laser shot	13.68 ± 6.84	11.96 ± 6.46	0.363
Laser power per shot, mJ	3.50 ± 0.89	3.61 ± 1.08	0.696
Total laser energy power, mJ	46.59 ± 23.20	43.30 ± 29.52	0.658
1st hour IOP change, mmHg	2.00 ± 3.63	0.04 ± 2.38	**0.025**
1st day IOP change, mmHg	1.07 ± 2.85	0.22 ± 1.88	0.224
3rd day IOP change, mmHg	0.61 ± 2.30	0.13 ± 1.74	0.416
7th day IOP change, mmHg	0.64 ± 2.02	− 0.09 ± 1.54	0.160

IOP intraocular pressure, *AOD* angle open distance, *ACA* anterior chamber angle

Bold values indicate significance at $p < 0.05$

Table 2 Clinical characteristics and measurements of eyes with anterior chamber angle above and below 40° in the temporal quadrant

Characteristic	Below 40° ($n = 28$)	Above 40° ($n = 23$)	p Value
Age, years	62.11 ± 12.33	65.74 ± 10.61	0.271
Pre-laser IOP, mmHg	12.68 ± 2.65	13.43 ± 3.44	0.379
Nasal AOD500, µm	714.79 ± 107.40	876.57 ± 176.53	**< 0.001**
Nasal AOD750, µm	852.14 ± 123.55	1023.91 ± 171.28	**< 0.001**
Nasal ACA, °	35.82 ± 3.37	43.74 ± 3.87	**< 0.001**
Temporal AOD500, µm	689.21 ± 109.74	860.83 ± 176.86	**< 0.001**
Temporal AOD750, µm	821.93 ± 146.45	1013.35 ± 156.45	**< 0.001**
Temporal ACA, °	34.71 ± 3.15	43.22 ± 2.93	**< 0.001**
Counts of laser shot	13.68 ± 6.61	11.96 ± 6.75	0.363
Laser power per shot, mJ	3.51 ± 0.90	3.60 ± 1.07	0.738
Total laser energy power, mJ	46.62 ± 22.41	43.26 ± 30.25	0.650
1st hour IOP change, mmHg	1.96 ± 3.66	0.09 ± 2.37	**0.032**
1st day IOP change, mmHg	1.21 ± 2.79	0.04 ± 1.89	0.082
3rd day IOP change, mmHg	0.64 ± 2.28	0.09 ± 1.76	0.343
7th day IOP change, mmHg	0.68 ± 2.04	− 0.13 ± 1.49	0.119

IOP intraocular pressure, *AOD* angle open distance, *ACA* anterior chamber angle

Bold values indicate significance at $p < 0.05$

antiglaucomatous treatment may be recommended. Ari et al. [9] stated that an increase in IOP is inevitable after laser capsulotomy, but the duration and severity are less when the total energy level is less than 80 mJ. However, Shani et al. [18] suggested that there is usually no IOP elevation after Nd:YAG laser capsulotomy in healthy pseudophakic eyes without additional risk factors. In a 3-month follow-up study by Hu et al. [19], no sustained increase was detected in IOP. Kim et al. [20] observed no significant difference in IOP at one-month follow-up after different Nd:YAG capsulotomy methods. Kraff et al. [21] found that IOP elevation after Nd:YAG capsulotomy returned to baseline in the first week in a pseudophakic group. However, in previous studies, IOP values were evaluated by administering antiglaucomatous treatments to some patients [18–21].

Singh et al. [11] reported that IOP increased in only 1 of 38 patients who were administered 50 mJ at most and that IOP declined to an insignificant level in 24 hours. Parajuli et al. [12] conducted a Nd:YAG laser capsulotomy study without antiglaucoma medication either before or after the procedure. In below 50 mJ group, IOP increased at 1st hour post-laser and decreased to pre-laser levels at 1 month [12].

In above 50 mJ group, IOP increased at 1st hour post-laser and did not return to pre-laser levels at 1-month follow-up [12]. In the current study, although IOP increased at the 1st hour after the procedure, it returned to baseline levels by the 7th day. Moreover, no relationship was determined between IOP change and the applied laser power or count.

Patients with glaucoma are more likely to need treatment for high IOP following Nd:YAG capsulotomy [4, 18]. As patients with glaucoma have impaired outflow facility prior to laser capsulotomy, they may be more susceptible to the effects of laser-induced particle debris and inflammation [4]. Increased IOP is more common in aphakic eyes after laser capsulotomy than in pseudophakic eyes, as the intraocular lens can both prevent the cortical material from reaching the trabecular meshwork and protect the trabeculum by absorbing pressure waves [4, 18, 21]. Capsulotomy dimensions may also be a factor. With a higher, wider capsulotomy, there may be a greater IOP increase independent of the energy used due to the inflammatory products released. Karahan et al. [10] suggested that IOP increased 1 week after laser and this increase was greater in the group with large laser capsulotomy size than in those where the capsulotomy was smaller. In the present study, the effects of these possible risk factors were precluded by excluding patients with aphakic eyes and glaucoma and keeping capsulotomy sizes standard.

Pekel et al. [22] examined the impact of Nd:YAG capsulotomy using a Pascal dynamic contour tonometer and Scheimpflug imaging system. The procedure was not found to significantly change IOP, ocular pulse amplitude, iridocorneal angle, or anterior chamber depth, but caused a temporary increase in central corneal thickness and corneal volume in the short term [22]. El-Haddad [23] studied the effect of Nd:YAG laser capsulotomy on anterior chamber morphology using AS-OCT. An increase was reported in ACA, AOD500, and AOD750 values, and no significant change was stated in IOP, anterior chamber depth, and central corneal thickness values [23]. The prescribing of antiglaucomatous treatment in both those studies may have prevented any change in IOP [22, 23]. In the current study conducted without antiglaucomatous medication, the increase in IOP was determined to be higher at the first hour after the procedure in eyes with narrower angle configuration.

The mechanism of increase in IOP in some laser capsulotomy cases and not in others remains unclear. Differences in ACA may contribute to these IOP spikes. A narrow ACA increases blockage of the trabecular meshwork drainage angle, resulting in a risk of IOP elevation [16, 24]. In cases with a narrow ACA, even with a low-energy procedure or small capsular opening, aqueous humor outflow through the trabecular meshwork pathway may be interrupted by the capsular material and inflammatory debris. In most cases, the absence of an increase in IOP may be attributed to adequate patency of the ACA.

The main limitations of this study were the relatively small sample size and short follow-up period. However, this is the first study to have evaluated anterior segment angle configuration using AS-OCT, in respect of the tendency to increased IOP in patients undergoing laser capsulotomy. Further studies with larger sample sizes are needed to better understand the underlying mechanism of IOP elevation. Evaluating patients with glaucoma as a separate group and analysis of shorter time points between the 1-h and 1-day time points may contribute to the literature.

In conclusion, except for the first hour after Nd:YAG laser capsulotomy, no significant increase in IOP was observed. In patients with ACA less than 40°, the increase in IOP was higher at the first hour after the procedure. Therefore, in patients with a narrow ACA, first-hour follow-up seems advisable in terms of susceptibility to increased IOP.

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Author contribution Design of the study (AK); conduct of the study (AK and SKK); analysis and interpretation (AK and SKK); literature search (AK and SKK); and critical review (AK and SKK).

Declarations

Ethics approval The study was approved by the Institutional Review Board/Ethics Committee of Ankara Training and Research Hospital, Ankara, Turkey (protocol no: E-20-460). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent for publication Obtained.

Conflict of interest The authors declare no competing interests.

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