Effect of Nd: YAG Laser Capsulotomy Size on Intraocular Lens Tilt and Decentration after Femtosecond Laser-Assisted Capsulotomy

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ABSTRACT

Purpose: To determine the effect of capsulotomy size on intraocular lens (IOL) tilt and decentration in eyes undergoing Nd:YAG laser capsulotomy due to posterior capsular opacification (PCO) following femtosecond laser-assisted (FSL) cataract surgery.

Materials and Methods: The study included 42 patients who underwent FSL-assisted standard 5.0-mm anterior capsulotomy followed by Nd:YAG laser capsulotomy at a mean of 16.2 (6–34) months after cataract surgery. The patients were divided based on Nd:YAG posterior capsulotomy size into the 3.5 mm group (22 eyes) and the 4.0 mm group (20 eyes). IOL tilt and decentration were measured with Scheimpflug camera before and at one month after Nd:YAG laser capsulotomy.

Results: Before capsulotomy, there were no differences between the 3.5 mm and 4.0 mm groups in terms of angle of tilt or decentration at either meridian ($p>0.05$). After capsulotomy, both groups showed significant decreases in angle of tilt (mean vertical/horizontal values: 1.4/1.2 degrees in the 3.5 mm group; 0.9/0.8 degrees in the 4.0 mm group) and significant increases in decentration (mean vertical/horizontal values: 0.10/0.11 mm in the 3.5 mm group; 0.27/0.24 mm in the 4.0 mm group) at both meridians compared to precapsulotomy measurements ($p<0.05$). After capsulotomy, all tilt and decentration parameters differed significantly between the two groups at both meridians ($p<0.05$ for all).

Conclusions: The diameter of Nd:YAG posterior capsulotomy performed after FSL-assisted cataract surgery affected the mechanical stability of the IOL, but the tilt and decentration values were very small and may not be clinically significant.

Keywords: Capsulotomy Size, Intraocular Lens Tilt, Intraocular Lens Tilt Decentration, Femtosecond Laser-Assisted Capsulotomy, Nd:YAG Laser.

INTRODUCTION

Modern cataract surgery aims to increase quality of life by providing patients good visual acuity. However, even with a well-executed cataract surgery, posterior capsule opacification (PCO) significantly impairs vision quality over time by reducing visual acuity and increasing photic phenomena such as halo and glare.[1]

Neodymium- yttrium aluminum garnet (Nd:YAG) laser capsulotomy is a standard treatment option for PCO that provides satisfactory outcomes for both patients and surgeons.[2] Nevertheless, Nd:YAG capsulotomy can occasionally result in serious clinical complications that require surgical treatment, such as retinal detachment, as well as conditions that can usually be controlled with medical treatment, such as elevated intraocular pressure and cystoid macular edema, and the relatively less important issues of IOL tilt and decentration, which can be measured using more sophisticated methods.[3-6] In order to achieve visual recovery after cataract surgery, it is crucial that the implanted IOL does not become decentered or tilted. Even if the IOL is positioned perfectly during in-the-bag implantation, subsequent tilt or decentration induces astigmatism and higher-order aberrations (HOAs) in the

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horizontal and vertical planes and myopic or hyperopic shift in the axial plane.[7-8]

Both the shape and size of the anterior capsule and the capsulotomy performed on the posterior capsule remaining from the crystalline lens after cataract surgery affect IOL tilt and decentration.[9-10] Although creating anterior capsular openings of standard size, circularity, and centration is possible with femtosecond laser (FSL)-assisted cataract surgery, it is not always possible to achieve a posterior capsule opening with standard size and circularity after Nd:YAG capsulotomy.

In this study, we investigated the effect of posterior capsule opening size on IOL tilt and decentration in patients who underwent Nd:YAG capsulotomy for PCO after FSL-assisted cataract surgery with anterior capsule openings of standard size and circularity.

MATERIALS AND METHODS

Our study was designed as a retrospective study. The study included a total of 42 patients who had impaired vision due to PCO following uncomplicated cataract surgery with FSL-assisted standard 5.0-mm anterior capsulotomy and in-the-bag implantation of the same model of IOL (AcrySof®, SA60AT, Alcon Laboratories) performed by the same surgeon (E.C.) between 2015 and 2018 in the Ekol Eye Hospital. FSL-assisted anterior capsulotomy was performed using a LenSx® laser system (Alcon, Fort Worth, TX, USA) set to 5 mJ energy, 4 µm spot size, and 4 µm layer separation.

All patients included in the study had presenting visual acuity less than or equal to 20/40 according to Snellen chart due to PCO. Diagnosis of PCO was based on the observation of opacities blocking the optic axis on slit-lamp examination. In accordance with the Declaration of Helsinki, the patients were informed about the Nd:YAG capsulotomy procedure and their informed consent was obtained. The study was approved by the Alanya Alaaddin Keykubat University School of Medicine Ethics Committee (No: 4-6/b-2018).

Exclusion criteria included history of ocular surgery or trauma, dislocated or subluxated lens, dilated pupil diameter less than 5.0 mm, uveitis, high myopia or hyperopia, pseudoexfoliation syndrome, retinal pathologies, glaucoma, or intraocular pressure over 21 mmHg. We also excluded patients who developed intraoperative or postoperative complications such as anterior capsular tear, posterior capsule rupture, zonular dialysis, or posterior synechia. Refractive error was estimated using an autorefractometer (Topcon KR-8800). Manifest refraction was used to determine corrected distance visual acuity (CDVA) and was accepted as the patient's actual refractive error. CDVA was assessed using a Snellen chart and converted to logMAR equivalent for statistical analysis.

Nd:YAG capsulotomy procedure

All posterior capsulotomies were performed in a single session by the same experienced surgeon using a Q-switched Nd:YAG laser (Optimis Fusion, Quantel Medical) with Abraham YAG laser capsulotomy lens (Ocular Instruments, Inc.). The capsulotomies were made as central and round as possible, and tension lines on the posterior capsule were targeted in a crisscross pattern to ease the enlargement of the capsulotomy opening. Independently of any patient characteristics, the Nd:YAG capsulotomies were created with vertical and horizontal diameter of approximately 3.5 mm in the first 22 consecutive patients and approximately 4.0 mm in the next 20 patients, based on the scale in the slit-lamp biomicroscope. Energy per shot, total spot count, and total energy delivered were recorded for each patient. All patients were prescribed fluorometholone eye drops 4 times a day for 1 week after Nd:YAG capsulotomy.

Measurement of Nd:YAG capsulotomy opening

One month after Nd:YAG capsulotomy, two different surgeons (E.C. and G.E.) who were blinded to the patients' capsulotomy sizes measured the horizontal and vertical dimensions of the patients' posterior capsulotomy openings on a computer using distance measurement software. Details of the measurement process were as follows: Before Nd:YAG capsulotomy, all patients underwent imaging using a high-resolution anterior segment camera (DC-3 camera, IMAGEnet i-base, Topcon, Japan) with coaxial light source mounted to the biomicroscope to visualize the edges of the IOL (Figure 1). After the Nd:YAG procedure, images were acquired again and transferred to a digital environment (Figure 2). The posterior capsulotomy openings were measured using the "Micro-measurements" program, a free mobile app that enables measuring from images (Figure 3). Making measurements with this software first requires marking a known distance on the transferred high-resolution digital image for calibration purposes. We used IOL diameter (6 mm) for this calibration value. The software then compares with the set calibration value to measure the distance of interest. The accuracy and repeatability of the measurements were assessed by having two different surgeons (E.C. and G.E.) independently measure the Nd:YAG capsulotomy openings on images of the same patients.

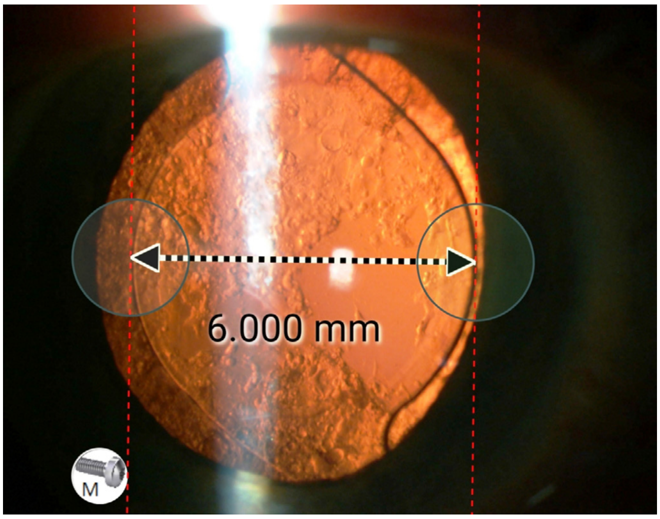

Figure 1: *Before Nd:YAG capsulotomy, patient underwent imaging by anterior segment camera with coaxial light source to visualize the edges of the IOL.*

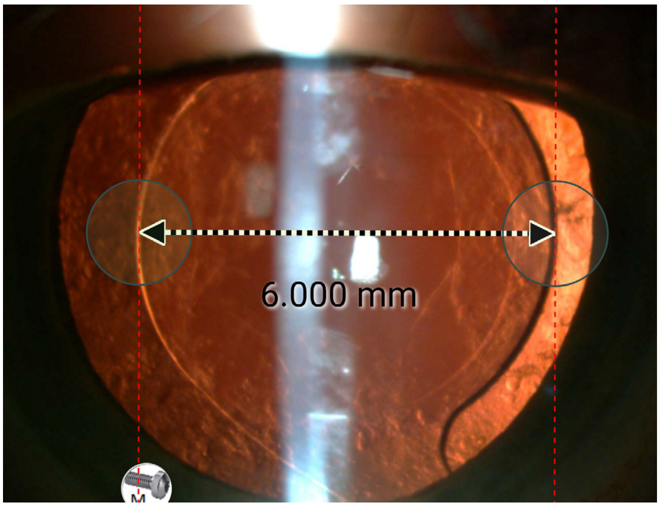

Figure 2: *After Nd:YAG capsulotomy, patient underwent imaging by anterior segment camera with coaxial light source to visualize the edges of the IOL, and border of posterior capsululotomy.*

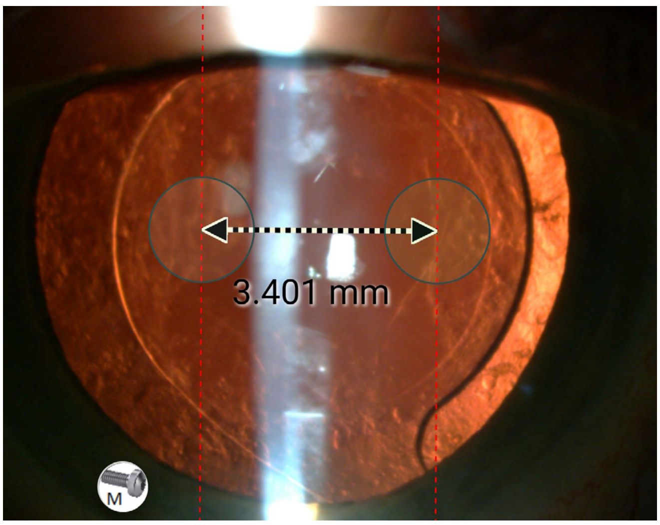

Figure 3: *Posterior capsulotomy openings were measured using the "Micro-measurements" program.*

Measurement of IOL tilt and decentration

As the method for measuring IOL tilt and decentration using the Scheimpflung imaging system has been explained in detail in previous studies, we will provide only a brief summary.[10-11] A Scheimpflug imaging system (Pentacam HR; Oculus Optikgerate GmbH, Wetzlar, Germany) was used to evaluate IOL tilt and decentration immediately before and at one month after posterior capsulotomy in all patients according to data from de Castro et al.[11] as follows: Cross-sectional images of the anterior chamber and IOL at the vertical and horizontal meridians were obtained through a dilated pupil and corrected for geometric distortion by the software in the Scheimpflug camera. To ensure consistency, the same physician (E.C.) performed all measurements and image processing procedures. The images were processed in the Adobe Photoshop CS5 program using the technique previously described by de Castro et al.[11] All images were color-inverted and contrast was further enhanced if necessary to facilitate identification of the anterior and posterior IOL edges. The IOL center was determined as the midpoint between the points of intersection of circumferences fitted to the anterior and posterior IOL edges. The center of the pupil was determined as the midpoint between the opposing ends of the iris. The distance between the IOL center and pupillary axis was accepted as IOL decentration. Positive horizontal coordinates correspond to nasal in the right eye and temporal in the left eye, while positive and negative vertical coordinates represent superior and inferior decentration, respectively. Taking absolute values yields horizontal and vertical decentration magnitudes independent of nasal/temporal or superior/inferior orientation. For IOL angle of tilt, positive tilt around the x-axis indicates the superior IOL edge is forward, while negative tilt indicates a forward inferior edge. Positive tilt around the y-axis represents nasal tilt (nasal edge of IOL is back) for right eyes and temporal tilt (nasal edge of IOL is forward) in left eyes. Again, using absolute values provides the degree of horizontal and vertical tilt independent of orientation. Detailed measurements in this study were done in reference to previous studies.[11]

Statistical analysis was performed using SPSS for Windows 21.0 (SPSS Inc, Chicago, IL). Continuous variables were assessed for normality using Kolmogorov-Smirnov test, which demonstrated normal distributions for all parameters. Therefore, descriptive statistics, Nd: YAG capsulotomy size, visual acuity, and IOL position parameters were expressed in mean±standard deviation (SD). Categorical variables were analyzed using chi-square test. All parameters were compared between the groups (3.5 mm and 4.0 mm) using independent samples t test. Repeated measures were compared within the groups using paired samples t-test. P value <0.05 was considered statistically significant. Intraclass correlation coefficient (ICC) was also used to assess concordance between the capsulotomy measurements made by the two researchers.

RESULTS

The study sample comprised 22 patients in the 3.5 mm capsulotomy group (12 female, 10 male; mean age 55.2±8.1 years) and 20 patients in the 4.0 mm capsulotomy group (10 female, 10 male; mean age 54.4±9.1 years). There were no statistically significant differences between the groups in terms of age (p=0.865) or sex distribution (p=0.914).

The mean interval between cataract surgery and laser capsulotomy was 16.1 (6-32) months in the 3.5 mm capsulotomy group and 16.4 (7-34) months in the 4 mm capsulotomy group (p=0.707).

The mean CDVA, spherical equivalent (SE), mean keratometry (K_{mean}), anterior chamber depth (ACD), pachymetry, anterior chamber (AC) volume, Axial Length (AL), and mean AC angle values of both groups before and after capsulotomy are shown in Table 1.

The correlation of the time elapsed between the cataract and laser surgeries and the amount of IOL tilt and decentralization had been evaluated. No significant correlation was found in both 3.5 mm and 4.0 mm groups (all p values p>0.05).

The mean energy per spot was 0.7 mJ; mean total spot count and mean total energy were 18.4 (6-37) shots and 16.2 (5-34) mJ in the 3.5 mm capsulotomy group and 17.9 (4-35) shots and 15.3 (5-33) mJ in the 4.0 mm capsulotomy group. Mean total energy and spot count did not differ significantly between the groups (mean total energy: p=0.605; mean shot count: p=0.745).

A single value for Nd:YAG capsulotomy opening size was obtained by calculating the arithmetic mean of the horizontal and vertical diameters. In the 3.5 mm group, mean capsulotomy diameters were determined as 3.44±0.21 mm and 3.47±0.34 mm using the measurements obtained by the two different researchers (ICC=0.92). Similarly, in the 4.0 mm group, mean capsulotomy size measured by the two researchers was 4.05±0.31 mm and 4.09±0.24 mm (ICC=0.90).

After capsulotomy, angle of tilt values were significantly decreased and decentration values were significantly increased at both meridians in both groups when compared with pre-capsulotomy values (p<0.05 for all) (Table 2). There were no significant differences between the groups in terms of tilt angle or decentration values in either meridian before capsulotomy (p>0.05) (Table 3). However, post-capsulotomy decentration and angle of tilt values at both the vertical and horizontal meridians were significantly different between the groups (Table 3). Figure 4 shows boxplot analyses of angle of tilt and decentration measurements in both groups (3.5 mm and 4.0 mm) before and after capsulotomy.

Pearson's correlation analysis was used to evaluate relationships between tilt angle and decentration and CDVA, SE, ACD, and AC volume and angle in both groups. None of these variables were significiantly correlated with angle of tilt or decentration at either meridian (Tables 4 and 5).

Table 1: *Both groups before and after capsulotomy.*

	3.5mm capsulotomy group			4.0mm capsulotomy group		
	Before capsulotomy	**After capsulotomy**	**p**	**Before capsulotomy**	**After capsulotomy**	**p**
CDVA	0.54±0.12	0.10±0.08	**<0.001***	0.59±0.09	0.10±0.04	**<0.001***
SE	0.819±0.84	0.701±0.83	0.412	0.834±0.73	0.768±0.79	0.807
K_{mean}	43.44±1.94	43.52±1.81	0.716	43.27±1.84	43.34±1.64	0.718
ACD	4.31±0.62	4.28±0.65	0.153	4.28±0.57	4.33±0.55	0.571
Pachymetry	529.59±31.2	531.84±29.9	0.853	531.22±29.2	530.21±27.1	0.743
AC volume	165.31±30.1	169.274±25.5	0.219	171.58±23.1	172.27±19.8	0.872
AC angle	63.17±8.34	64.15±7.66	0.434	64.21±7.37	65.16±8.91	0.446
AL	22.14±1.43	22.21±1.17	0.804	22.28±1.73	22.35±1.09	0.809

CDVA: Corrected distance visual acuity, **SE:** Mean spherical equivalent, **Kmean:** Mean Keratometric values, **ACD:** Anterior chaber depth, **AC volume:** Anterior chamber volume, **AC Angle:** Anterior chamber angle. **AL:** Axial Length, * p values considered as statistically significant.

Table 2: *The angle of the tilt and decentration measurements of the IOL at the vertical and horizontal meridians before and after capsulotomy in both groups.*							
Intraocular lens position		**3.5mm capsulotomy group**			**4.0mm capsulotomy group**		
		Before capsulotomy	**After capsulotomy**	**P1**	**Before capsulotomy**	**After capsulotomy**	**P2**
Vertical meridian	Angle of tilt (degree)	3.829±0.74	2.355±0.97	**0.001***	3.809±0.46	2.838±0.59	**0.001***
	Decentration (mm)	0.438±0.34	0.581±0.24	**0.043***	0.465±0.35	0.748±0.35	**0.048***
Horizontal meridian	Angle of tilt (degree)	3.753±0.54	2.547±0.62	**0.001***	3.832±0.64	2.969±0.75	**0.002***
	Decentration (mm)	0.525±0.31	0.614±0.25	**0.042***	0.511±0.30	0.733±0.38	**0.043***

* p values considered as statistically significant. p1; compare to baseline and after capsulotomy in 3.50 mm capsulotomy group p2; compare to baseline and after capsulotomy in 4.0 mm capsulotomy group.

Table. 3: *The angle of the tilt and decentration measurements of the IOL at the vertical and horizontal meridians compare to baseline and baseline or after and after capsulotomy at both groups.*							
Intraocular lens position		**3.5mm capsulotomy group compare to 4.0mm capsulotomy group**					
		Before capsulotomy 3.5 mm group	**Before capsulotomy 4.0 mm group**	**P1**	**After capsulotomy 3.5 mm group**	**After capsulotomy 4.0 mm group**	P2
Vertical meridian	Angle of tilt (degree)	3.829±0.74	3.809±0.46	0.952	2.355±0.97	2.838±0.59	**0.047***
	Decentration (mm)	0.438±0.34	0.465±0.35	0.903	0.581±0.24	0.748±0.35	**0.042***
Horizontal meridian	Angle of tilt (degree)	3.753±0.54	3.832±0.64	0.637	2.547±0.62	2.969±0.75	**0.044***
	Decentration (mm)	0.525±0.31	0.511±0.30	0.839	0.614±0.25	0.733±0.38	**0.047***

p1; compare to baseline (before capsulotomy) values in both grup p2; compare to after capsulotomy in both group.
* p values considered as statistically significant.

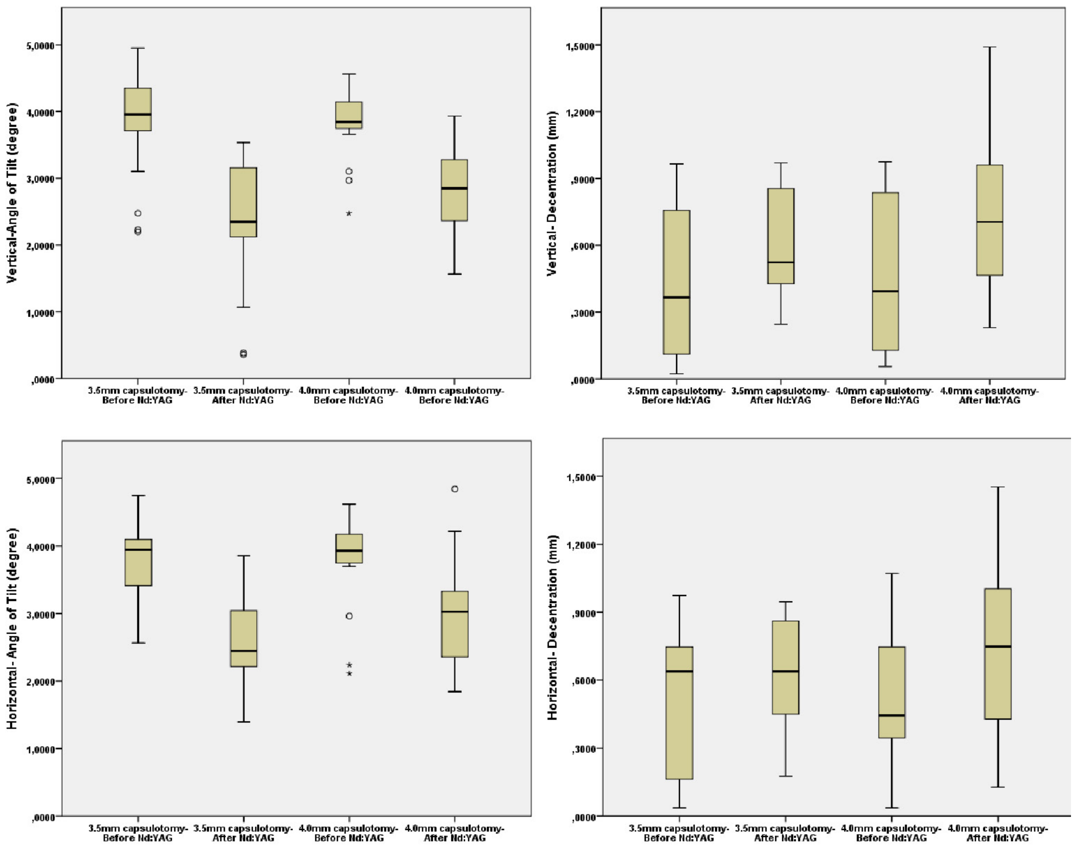

Figure 4: *Boxplot analyses shows angle of tilt and decentration measurements in both groups (3.5 mm and 4.0 mm) before and after Nd:YAG capsulotomy.*

Table 4: *Pearson's analysis in the 3.5mm capsulotomy group.*

	Vertical meridian				Horizontal meridian			
	Angle of tilt (degree)		Decentration (mm)		Angle of tilt (degree)		Decentration (mm)	
	r	p	r	p	r	p	r	p
CDVA	0.217	0.803	0.114	0.685	0.317	0.813	0.222	0.376
SE	0.264	0.437	0.318	0.327	0.501	0.147	0.137	0.473
ACD	0.284	0.203	0.386	0.817	0.061	0.707	0.432	0.213
AC volume	0.254	0.374	0.208	0.541	0.339	0.884	0.291	0.343
AC angle	0.158	0.807	0.446	0.637	0.112	0.784	0.127	0.292
AL	0.104	0.983	0.119	0.909	0.128	0.918	0.203	0.948

CDVA; Distance corrected visual acuity, **SE:** Spheric equivalent, **ACD:** Anterior chamber depth, **AC volume:** Anterior chamber volume, **AC angle:** Anterior chamber angle, **AL:** Axial Length

Table 5: *Pearson's analysis in the 4.0mm capsulotomy group.*

	Vertical meridian				Horizontal meridian			
	Angle of tilt (degree)		Decentration (mm)		Angle of tilt (degree)		Decentration (mm)	
	r	P	r	p	r	p	r	p
CDVA	0.412	0.317	0.195	0.322	0.284	0.497	0.212	0.538
SE	0.322	0.133	0.117	0.735	0.102	0.845	0.216	0.327
ACD	0.278	0.512	0.138	0.704	0.422	0.236	0.404	0.122
AC volume	0.244	0.296	0.397	0.291	0.101	0.507	0.126	0.546
AC angle	0.208	0.174	0.303	0.333	0.235	0.514	0.278	0.243
AL	0.201	0.728	0.254	0.750	0.282	0.768	0.219	0.739

CDVA; Distance corrected visual acuity, **SE:** Spheric equivalent, **ACD:** Anterior chamber depth, **AC volume:** Anterior chamber volume, **AC angle:** Anterior chamber angle, **AL:** Axial Length

DISCUSSION

Since Thornval and Naeser[12] performed ACD measurements to obtain information about IOL mobility after Nd:YAG capsulotomy, a growing number of studies have been conducted to understand the effect of Nd:YAG capsulotomy on IOL mobility. In the present study, we examined the effect of different Nd:YAG posterior capsulotomy opening sizes on IOL tilt and decentration in patients with anterior capsular openings of equal size and circularity created during standardized FSL-assisted cataract surgery. We determined that capsulotomy openings 3.5 mm in diameter were associated with less IOL tilt and decentration compared to capsulotomies 4.0 mm in diameter. In eyes with 5.0-mm FSL anterior capsulotomies, posterior capsulotomy opening size had a significant effect on IOL tilt and decentration.

Anterior and posterior IOL movement causes refractive shift; movement in the vertical and horizontal planes lead to decentration; and malposition in the coronal plane leads to tilt. Due to the close association between IOL tilt/decentration and halo, glare, and HOAs reported in previous studies, capsulotomy size may be important in the reduction of such photic phenomena.[13-14]

An anterior capsular opening that is centered, appropriately sized, and leaves adequate overlap over the IOL surface has a key role in preventing the development of IOL decentration and tilt, refractive shift, and anterior and posterior capsular opacities.[15] Szigeti et al.[16] compared IOL tilt and decentration in two different pseudophakic (single-optic accommodating IOL) patient groups who underwent FSL-assisted anterior capsulotomy with openings of 5.5 mm and 6.0 mm. They observed that none of the patients in the 5.5 mm anterior capsulotomy group had tilt greater than 5 degrees or decentration greater than 0.4 mm, whereas in the 6.0 mm group, 2 patients (25%) had more than 5 degrees of tilt and 3 patients (37.5%) had more than 0.4 mm decentration. Hayashi et al.[17] reported 0.24 mm decentration and 1.68 degrees of tilt in 56 patients 6 months after standard cataract surgery with one-piece IOL implantation. The authors stated that as little as 0.1 mm of decentration and 1 degree of tilt can be clinically significant. Altmann et al.[18] and Holladay et al.[19] showed that the asphericity of aspheric IOLs was substantially reduced with decentration greater than 0.5 mm and 0.4 mm, respectively. In the present study, none of the patients in the 3.5 mm Nd:YAG posterior capsulotomy group exhibited over 5 degrees of tilt, while decentration greater than 0.5 mm was noted in 2 patients. In the 4.0 mm group, tilt exceeding 5 degrees was detected in 1 patient and decentration greater than 0.5 mm in 4 patients. Our results show that although Nd:YAG posterior capsulotomy reduced tilt and increased decentration in both groups, both tilt and decentration values were higher with larger capsulotomy opening size. Because the anterior capsular opening, IOL type and YAG laser energy parameters are the same in our study, we explain the reduction in IOL tilt with the decrease of the tractional forces of fibrosis on IOL. Hayasi et al.[17] demonstrated 1.68 degree increase in IOL tilt and 0.24 degree increase in IOL decentralization, 6 months after the cataract surgery. Resolution of the capsular fibrosis by YAG Laser may resulted in reduction of the IOL tilt, as in this study.

Kranitz et al.[20] postoperatively evaluated vertical and horizontal IOL decentration, degree of IOL overlap (shortest and longest distance between capsulorhexis edge and IOL optic edge), and capsule circularity in 20 pseudophakic patients without PCO who underwent FSL-assisted anterior capsulotomy and 20 pseudophakic patients who underwent manual capsulorhexis, based on data obtained by processing images acquired with retroillumination using image analysis tools in the Adobe Photoshop software. They reported that IOL degree of overlap was better and vertical and horizontal decentration were less in eyes that underwent FSL-assisted anterior capsulotomy compared to those that had manual capsulorhexis, and concluded that anterior capsular opening is important for IOL stabilization. The studies by Sziget et al.[16] and Kranitz et al.[20] demonstrate the importance of anterior capsule opening size, circularity, and degree of overlap in terms of tilt and decentration, while our study emphasizes the importance of Nd:YAG posterior capsulotomy size in tilt and decentration for patients with an existing round, well-centered anterior capsulotomy.

Uzel et al.[6] compared IOL tilt and decentration measured using Scheimpflug camera in 29 eyes with PCO with 35 pseudophakic eyes without PCO. They found that eyes with PCO exhibited greater IOL tilt and decentration prior to Nd:YAG capsulotomy and showed that tilt was reduced while decentration increased after Nd:YAG capsulotomy in these eyes. Uzel et al. stated that posterior capsulotomy size was 4.0 mm in all patients but did not the measure the capsulotomy openings postoperatively. In the present study, postcapsulotomy evaluations in both groups revealed significantly decreased angle of tilt (mean vertical/horizontal values: 1.4/1.2 degrees in the 3.5 mm group; 0.9/0.8 degrees in the 4.0 mm group) and significantly increased decentration (mean vertical/horizontal values: 0.10/0.11 mm in the 3.5 mm group; 0.27/0.24 mm in the 4.0 mm group) at both meridians compared to precapsulotomy measurements ($p<0.05$). Furthermore, all tilt and decentration parameters at both meridians differed significantly between the two groups after capsulotomy. As in the study by Uzel et al., our results are consistent with decreased tilt and increased decentration after Nd:YAG capsulotomy. Moreover, they indicate that a 0.5-mm difference in Nd:YAG posterior capsulotomy size had a significant impact on IOL tilt and decentration. In one of our recent studies, we showed that in eyes with 4.0 mm posterior capsulotomies, IOL tilt and decentration after Nd:YAG capsulotomy were lower and IOL stability was better in the eyes that had FSL-assisted anterior capsulotomy with compared to manual capsulorhexis.[10] Our results indicate that 3.5-mm posterior capsulotomy causes less IOL tilt and decentration than 4.0-mm posterior capsulotomy in patients who underwent standardized FSL-assisted anterior capsulotomy.

Findl et al.[21] investigated the effect of differences in anterior capsulotomy circularity and size on IOL tilt and decentration in 255 eyes classified into three groups: a control group (smooth and centered capsulorhexis 4.5-5.5 mm in diameter), small capsulorhexis group (diameter less than 4.5 mm), and eccentric capsulorhexis group (>5.5 mm diameter and paracentral position). When the three groups were compared at postoperative 3 months, no significant difference was found in terms of ACD or IOL tilt, while IOL decentration differed significantly in the eccentric capsulorhexis group. Moreover, Findl found that ACD was significantly larger in 41 of 635 screened eyes whose anterior capsule did not adequately overlap the IOL surface, but their results indicated that capsulorhexis size and shape had little effect on the capsular bag performance of modern IOLs. In our study, we did not detect a significant correlation between ACD and tilt or decentration in either group. Although we tried to create Nd:YAG posterior capsulotomies as smooth and centered as possible, we did not perform any postoperative measurements regarding centration of the capsulotomy opening.

Clinical trials have demonstrated that smaller capsulotomies (2-3 mm) are as effective as larger ones (5-6 mm) in terms of visual acuity.[22-23] Based on the results of our study, which showed no significant difference in visual acuity or ACD but significant differences in IOL tilt and decentration between eyes with 3.5 mm and 4.0 mm capsulotomies, we believe that the commonly used capsulotomy size of 4.0 mm as recommended by Holladay et al. is appropriate.

Several studies have investigated the correlation between visual acuity and IOL tilt and decentration. In their study on a model eye with 6 different IOLs, Lawu et al.[24] reported reduced optic performance of the IOLs due to increased HOAs caused by IOL tilt and decentration. Impaired retinal image quality has been reported previously by Taketani et al.[25] due to coma-like aberrations induced by tilt and decentration and by Korynta et al.[26] due to increased refractive effect with increased tilt and decentration. Although we observed no significant difference relationship between visual acuity and tilt/decentration in either the 3.5 or 4.0 mm capsulotomy group, we did not perform a separate correlation analysis of HOA values.

Measuring posterior capsulotomy size after Nd:YAG capsulotomy is another problem. Although anterior segment imaging methods such as Scheimpflug camera can efficiently measure parameters such as AC angle, crystalline lens thickness, ACD, and pupillary diameter, it is usually not possible to achieve good localization and a high-quality image of the posterior capsule in pseudophakic patients due to the iris, anterior capsule opacity, or corneal haze and opacities. Transfering images acquired using advanced modalities and converting them into higher-resolution images from which numerical data can be obtained using another program is a frequently used method in ophthalmology practice. Hayashi et al.[27] assessed anterior capsule contraction in pseudophakic patients by measuring anterior capsular opening area and Hu et al.[28] measured change in posterior capsulotomy area over time in patients who underwent Nd:YAG capsulotomy using the Scheimpflug videophotography system (EAS-1000; Nidek Inc, Gamagori, Japan); Aslam et al.[29] used Scion Image software to measure the effect of capsulotomy size on visual performance after Nd:YAG capsulotomy; and Findl et al.[21] used Automated Quantification of After-Cataract (AQUA) software to assess the effect of capsulorhexis size and circularity on IOL tilt and decentration. Most programs measure area or dimension of interest using a structure (usually IOL) with a known length or area as the calibration value. In the present study we used a similar method in which images of eyes under coaxial retroillumination were acquired using a biomicroscope-mounted camera and evaluated using a simple measurement program. To reduce measurement errors and demonstrate repeatability, the measurements were performed by two different people. Based on the 95% confidence interval of the ICC estimates, values less than 0.5 indicate poor reliability, 0.5-0.75 moderate reliability, 0.75-0.9 good reliability, and greater than 0.90 reflect excellent reliability.[30] In our study, ICC values at 95% confidence interval were 0.92 and 0.90 for the 3.5 mm and 4.0 mm capsulotomy groups, respectively. We believe that these programs, which are simple and useful but always subject to human error, can be used for scientific purposes in ophthalmology practice until the development of automated systems that identify IOL contours and perform direct measurements.

One limitation of our study was the small number of patients. In addition, we did not measure degree of IOL overlap or centration of the posterior capsulotomy opening, which may affect IOL tilt and decentration. HOAs induced by IOL tilt and decentration were also not assessed. Moreover, as the effect of Nd:YAG capsulotomy opening on IOL tilt and decentration in patients who underwent FSL-assisted anterior capsulotomy has not been studied previously, our findings should be corroborated by other studies.

In eyes with smooth, centered anterior capsulotomy made using FSL, the size of the posterior capsulotomy opening created in Nd:YAG capsulotomy affects IOL tilt and decentration. Although larger posterior capsulotomy sizes increase IOL tilt and decentration, if they remain within the limits reported in the literature, it may not be clinically significant because visual acuity and ACD are not affected.

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This work has not been presented.

CONFLICT OF INTEREST

None of the authors has any conflict of interest with the submission

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