Anterior Segment Optical Coherence Tomography Assessment After Laser Capsulotomy in Pseudophakic Eyes With Pseudoexfoliation

Mustafa Eliacik, M.D., Sevil Karaman Erdur, M.D., Gokhan Gulkilik, M.D., Mustafa Ozsutcu, M.D., Cengiz Aras, M.D., Huseyin Bayramlar, M.D., and Cemile Anil Aslan, M.D.

Purpose: To assess changes in anterior-chamber depth (ACD) and angle width after neodymium:yttrium aluminum garnet (Nd:YAG) laser capsulotomy pseudophakia in eyes with pseudoexfoliation (PEX).

Methods: This prospective and interventional case series study included 25 pseudophakic eyes of 25 patients with PEX and 26 pseudophakic eyes of 26 patients without PEX scheduled for Nd:YAG laser capsulotomy in a single institution. Anterior-chamber depth and angle width were measured with anterior segment optical coherence tomography before and three days after Nd:YAG laser capsulotomy. Preoperative and postoperative measurements of ACD and angle width included the angle opening distance (AOD), measured as the perpendicular distance from the trabecular meshwork at 500 and 750 mm anterior to the scleral spur to the anterior iris surface (AOD500 and AOD750, respectively) and anterior-chamber angle (ACA) in the nasal and temporal quadrants. Main outcome measures were the changes in ACD and angle width parameters.

Results: The mean ACD, AOD500, AOD750, and ACA (nasal and temporal) measurements were 3.67±0.12 mm, 0.63±0.05 mm and 0.65±0.05 mm, 0.67±0.06 mm and 0.77±0.04 mm, 35.25±1.69° and 35.37±1.68° in eyes with PEX and 3.73±0.11 mm, 0.6±0.05 mm and 0.63±0.05 mm, 0.66±0.06 mm and 0.74±0.06 mm, 34.24±1.6° and 34.6±1.47° in control eyes, respectively ($P>0.05$ for all). After Nd:YAG laser capsulotomy, mean ACD, AOD500, AOD750, and ACA (nasal and temporal) measurements were 3.76±0.09 mm, 0.73±0.05 mm and 0.76±0.05 mm, 0.75±0.06 mm and 0.87±0.04 mm, 36.82±1.46° and 35.06±1.52° in eyes with PEX and 3.77±0.1 mm, 0.68±0.06 mm and 0.72±0.06 mm, 0.72±0.05 mm and 0.84±0.06 mm, 34.95±1.4° and 35.79±1.36° in control eyes, respectively ($P=0.811$, $P=0.019$, $P=0.021$, $P=0.109$, $P=0.126$, $P=0.001$, and $P=0.01$, respectively).

Conclusions: The depth and width of the anterior chamber in eyes with PEX and in control eyes increased significantly after Nd:YAG laser capsulotomy. The change in the width of the anterior chamber in eyes PEX was statistically significant comparing control eyes.

Key Words: Nd:YAG laser capsulotomy—Posterior capsule opacification—Pseudoexfoliation—Anterior-chamber depth—Anterior-chamber angle width—Anterior segment optical coherence tomography.

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From the Department of Ophthalmology (M.E., S.K.E., G.G., M.O., C.A., C.A.A.), Istanbul Medipol University School of Medicine, Istanbul, Turkey; and Department of Ophthalmology (H.B.), Medeniyet University School of Medicine, Istanbul, Turkey.

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Address correspondence to Sevil Karaman Erdur, M.D., Medipol University Medicine Faculty, Ophthalmology Department Istanbul, Turkey 34214; e-mail: sevilkaraman@yahoo.com

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Anterior segment optical coherence tomography (AS-OCT) is a noncontact method providing high-resolution direct cross-sectional images of anterior segment that can be analyzed and measured.[1,2] Anterior segment optical coherence tomography using 1.3 μm wavelength of light offers optimal visualization of angle structures and demonstrates good repeatability and reproducibility with low intraobserver and interobserver variability.[3–7]

The pseudoexfoliation (PEX) syndrome is a common age-related condition characterized by pathological accumulation of abnormal microfibrillar deposits on the aqueous-bathed surfaces of ocular tissues. It was first described in 1917 by Lindberg. It is more prevalent among older individuals and in women than in men.[8,9] Pseudoexfoliation affects 10% to 20% of people older than 60 years worldwide, and it is easily diagnosed by slitlamp examination.[10] Zonular instability is one of the most important ocular manifestations associated with PEX syndrome. The accumulation of pseudoexfoliative material on the suspensory ligaments of the lens made these zonular fibers fragile and vulnerable to mechanical events during surgical procedures and may lead to "late in-the-bag intraocular lens (IOL) dislocation."[11] Late in-the-bag IOL dislocation may occur during postoperative period spontaneously or after neodymium:yttrium aluminum garnet (Nd:YAG) laser capsulotomy.[12–14]

The object of this study was to evaluate changes in anterior-chamber depth (ACD) and angle width after Nd:YAG laser capsulotomy using AS-OCT in patients with PEX syndrome.

METHODS

This study included 25 eyes of 25 pseudophakic patients (13 females, 12 males) with PEX (group 1) and 26 eyes of 26 pseudophakic control patients (13 males, 13 females) (group 2).

All of the objects had symptomatic capsule opacification (PCO) and presented for Nd:YAG laser posterior capsulotomy at Medipol University School of Medicine, Department of Ophthalmology between November 20, 2013 and April 25, 2014. The study used an interventional case series design. Patients who underwent uncomplicated phacoemulsification surgery with a hydrophobic square-edged posterior-chamber IOL (Alcon IQ, Fort Worth, TX) at least six months before posterior capsulotomy and who experienced PCO that deteriorated visual acuity were included in the study. The mean time between posterior capsulotomy and cataract surgery was 17.23±6.8 months (range: 8–35 months) and

19.23±7.1 months (range: 6–32 months) in group 1 and 2, respectively.

The inclusion criteria in eyes with PEX were previously diagnosed with cataract with or without a white pupillary ruff and the presence of a manifest PEX deposition pattern in the anterior lens capsule and underwent uneventful cataract surgery. Control group was comprised normal eyes with senile cataract that underwent uneventful cataract surgery and the absence of coexisting ocular pathology.

Exclusion criteria for both groups were eyes lacking clear corneas or those having posterior segment pathologies, previous intraocular surgery other than uneventful phacoemulsification, ocular trauma or other intraocular pathology, or who were unable to understand the study or communicate. The study protocol was approved by the Ethics Committee of Medipol University. The tenets of the Declaration of Helsinki were followed, and all patients provided informed consent before enrollment.

All patients underwent routine ophthalmic examinations including visual acuity, Goldmann tonometry, slitlamp biomicroscopy, and fundoscopy before and three days after Nd:YAG laser capsulotomy. Refractive errors were measured as manifest refraction. The AS-OCT measurements were performed by two experienced technicians before and three days after the Nd:YAG laser capsulotomy using a Visante AS-OCT device (Carl Zeiss Meditec, Inc, Dublin, CA). Technicians were blinded to clinical ophthalmic examination results. For the measurements, pupils were undilated, and patients were asked to sit and fixate on an indicator in the AS-OCT under identical lighting conditions. Images of the nasal and temporal angle quadrants (0° and 180° meridians) were captured until the centration and quality were sufficient for analysis. The best images were selected and analyzed using custom software (Iridocorneal Module; Carl Zeiss Meditec, Inc) to detect changes by Nd:YAG laser capsulotomy above ACD and anterior-chamber angle (ACA).

All Nd:YAG laser capsulotomies were performed using a Q-switched Nd:YAG laser (YC-1600; Nidek Japan) by the same surgeon (M.E.). The procedure was performed in 18 right eyes and 25 left eyes. After explaining the procedure and obtaining informed consent, one drop of tropicamide 0.5% and one drop of phenylephrine 2.5% were instilled in each eye. Twenty to 30 minutes later, a standard Abraham capsulotomy lens was applied after topical application of oxybuprocaine hydrochloride 0.4% eye drops. The capsulotomy was fashioned in a cross pattern to create at least a 4 mm diameter opening. Details of the number of laser pulses and energy used were recorded. The mean energy level used was 1.43±0.14 mJ with a mean of 24±9 laser pulses and 1.44±0.15 mJ with a mean of 22±12 laser pulses in eyes with PEX and eyes without PEX, respectively. After the procedure, topical apraclonidine 1%, timolol 0.5%, dexamethasone sodium phosphate, and diclofenac sodium 0.1% drops were instilled. Intraocular pressure was measured one hr after the procedure. Dexamethasone sodium phosphate and diclofenac sodium 0.1% drops, four times per day, were prescribed for two weeks.

Anterior-chamber depth is defined as the distance from the endothelium to the anterior pole of IOL at the center of the cornea. We calculated ACA width by measuring the angle between the iris tangential line and the posterior corneal surface with its apex in the angle recess. Anterior-chamber angle width was also analyzed using standardized angle parameters after manual identification of the apex of the iris recess and scleral spur. Angle opening distances (AOD) at 500 μm (AOD500) and AOD at 750 μm (AOD750) were measured as the perpendicular distances measured from the trabecular meshwork at 500 and 750 μm, respectively, anterior to the scleral spur to the anterior iris surface (Fig. 1).[15]

All statistical analyses were performed using SPSS version 20 (SPSS Inc., Chicago, IL). We compared preoperative and postoperative angle measurements and ACD within each group using a paired *t* test. Independent *t* test is used to compare preoperative and postoperative angle measurements and ACD between two groups. A Kolmogorov–Smirnov test was used to test for normality between samples, followed by a Levene test to assess equal variances. All *P* values were 2-sided and were considered statistically significant when less than 0.05.

RESULTS

The mean age of subjects with PEX and controls was 64.15±3.99 years (range, 58–72 years) and 63.06±3.49 years

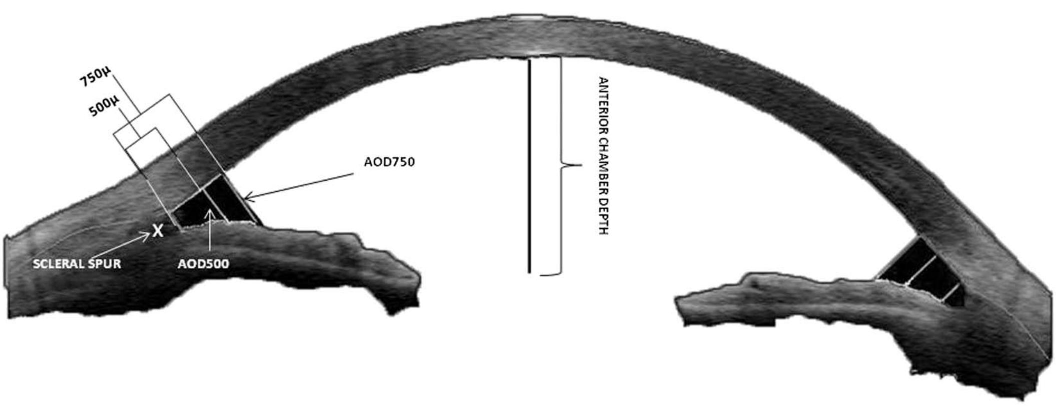

FIG. 1. Schematic representation of AS-OCT ACA measurement. Angle opening distances at 500 μm (AOD500) and AOD at 750 μm (AOD750) were measured as the perpendicular distances measured from the trabecular meshwork at 500 and 750 μm, respectively, anterior to the scleral spur to the anterior iris surface. ACA, anterior-chamber angle; AS-OCT, anterior segment optical coherence tomography.

(range, 56–69 years), respectively. There was no statistically significant difference with respect to gender and age between groups ($P>0.05$). Mean intraocular pressure was 16.9±2.1 mm Hg before capsulotomy and 19.1±2.04 mm Hg after capsulotomy in eyes with PEX, 16.1±2.7 mm Hg after capsulotomy, and 19.3±2.6 mm Hg after capsulotomy in normal eyes ($P>0.05$). Mean axial length was 22.84±0.78 mm in eyes with PEX and 22.85±0.74 mm in normal eyes ($P>0.05$).

There was no statistically significant difference among the groups regarding ACD after capsulotomy, AOD750 before and after capsulotomy in both temporal and nasal quadrants. All nasal and temporal angle parameter values analyzed by AS-OCT showed a significant increase after capsulotomy in both eyes with PEX and control eyes. The mean postcapsulotomy nasal angle increase was 1.57° (widening of 4.5%), and temporal angle increase was 1.69° (widening of 4.8%) in eyes with PEX. The corresponding values for controls were 0.71° (widening of 2%) and 1.19° (widening of 3.4%), respectively. The differences were statistically significant in nasal and temporal quadrants ($P=0.001$ and $P=0.01$, respectively). Table 1 shows the mean values of ACD, ACAs, standardized angle parameters (AOD500 and AOD750) in the nasal and temporal quadrants for eyes with PEX, and controls.

TABLE 1. *Comparison of Changes in Anterior-Chamber Parameters Before and After Nd:YAG Laser Capsulotomy With Anterior Segment OCT Between Two Groups*

Parameter	Eyes With PEX, Mean±SD	Eyes Without PEX, Mean±SD	*P**
Before laser capsulotomy			
ACD (mm)	3.67±0.12	3.73±0.11	0.144
ACA-nasal (degrees)	35.25±1.69	34.24±1.6	0.088
ACA-temporal (degrees)	35.37±1.68	34.6±1.47	0.14
AOD500-nasal (mm)	0.63±0.05	0.6±0.05	0.143
AOD500-temporal (mm)	0.65±0.05	0.63±0.05	0.177
AOD750-nasal (mm)	0.67±0.06	0.66±0.06	0.165
AOD750-temporal (mm)	0.77±0.04	0.74±0.06	0.205
After laser capsulotomy			
ACD (mm)	3.76±0.09	3.77±0.1	0.811
ACA-nasal (degrees)	36.82±1.46	34.95±1.4	0.001
ACA-temporal (degrees)	35.06±1.52	35.79±1.36	0.01
AOD500-nasal (mm)	0.73±0.05	0.68±0.06	0.019
AOD500-temporal (mm)	0.76±0.05	0.72±0.06	0.021
AOD750-nasal (mm)	0.75±0.06	0.72±0.05	0.109
AOD750-temporal (mm)	0.87±0.04	0.84±0.06	0.126

ACA, anterior-chamber angle; ACD, anterior-chamber depth; AOD500, angle opening distance 500 μm anterior to the scleral spur; AOD750, angle opening distance 750 μm anterior to the scleral spur; OCT, optical coherence tomography; PEX, pseudoexfoliation; SD, standard deviation.

*Independent *t* test.

DISCUSSION

Pseudoexfoliation syndrome has been described as a cause of glaucoma according to the characteristic changes of the anterior lens capsule nearly a century ago.[9] The hallmark of PEX syndrome is the pathologic production and accumulation of an abnormal fibrillar extracellular material in anterior segment tissues.[8] In recent years, it has been described a broad spectrum of intraocular complications associated with PEX syndrome. According to ultrastructural research, PEX fibrils seem to be composite by different intraocular cell types, which may explain the wide range of intraocular complications including corneal endothelial decompensation, zonular weakness, intraocular hemorrhage from the iris, vitreous loss with posterior capsular rupture, postoperative inflammation and intraocular pressure spikes, earlier secondary cataract, and decentralization or late dislocation of intraocular lens.[10] Perhaps the most serious complications on eyes with PEX during surgery are zonular weakness, which can be attributed to pseudoexfoliative material that affects zonular fibers with proteolytic mechanisms.[10,11]

Kuchle et al.[16] found that ACD was significantly smaller in eyes with PEX than normal eyes, and this could be attributed to zonular instability. It has been considered that this difference may be responsible for increased rate of capsular complications in the eyes with PEX.[16,17] This study, however, showed no significant difference in ACD between the eyes with and without PEX.

Auffarth et al. examined a series of 24 autopsy eyes with PEX that had undergone cataract surgery and IOL implantation. The results indicate that the insufficient suspension apparatus of the lens and decentralization of the entire capsular bag are the main reasons for IOL decentralization in patients with PEX.[18] Bosnar et al.[19] proposed that optical low-coherence reflectometry may be used preoperatively in eyes with PEX to detect the zonular weakness and subsequent lens instability, which documented as significantly shallower anterior chamber, thicker lens, and smaller pupillary diameter. Kuchle et al. observed an earlier and significantly higher frequency of secondary cataract in eyes with PEX after extracapsular cataract extraction. They considered the impairment of the blood-aqueous barrier in PEX eyes as a risk factor for early development of secondary cataract.[20] Hohn et al. reported delayed spontaneous dislocation of the IOL, and capsule in patients with PEX syndrome after postoperatively occurring secondary cataract was treated by a YAG capsulotomy in four cases. None of these patients had any other predisposing factors that would lead to zonular weakness except PEX syndrome.[13] Our results are consistent with those studies.

In our previous study, we reported that the depth and width of the ACA in pseudophakic eyes with PCO increased significantly after Nd:YAG laser capsulotomy as shown by AS-OCT. In that study, we also observed that the different angle parameters such as ACD, AOD500, AOD750, and ACA measurements were highly correlated.[15] We concluded that shock waves associated with Nd:YAG laser may cause mechanical effects on zonules, leading to IOL position shift by vitreous cavitation. In this study, the depth and width of the ACA in pseudophakic eyes with PEX after Nd:YAG laser capsulotomy increased more than control eyes. The difference was statistically significant. It is well known that eyes with PEX are prone to zonular weakness. We believe that this study strengthens our hypothesis about mechanical effects of Nd:YAG laser on zonules. As the zonules in pseudophakic eyes with PEX are probably weaker than control eyes, the mechanical effect of Nd:YAG laser on zonules might have been more powerful in pseudophakic eyes with PEX than control eyes.

Despite several limitations such as short follow-up and small number of patients, we think that this study is enough to draw a conclusion that the ACD deepens and angle widens after YAG capsulotomy, especially in the eyes with PEX, and this can be shown well by AS-OCT.

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