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Original article

Anterior Segment Optical Coherence Tomography Of Anterior Lens Capsule in Pseudo-Exfoliation Syndrome

Al-Shimaa A. Mostafa, Mohammed H. El Hetow, Ayser A. Fayed, Ahmed A. Shebl

Department of Ophthalmology Faculty of Medicine; Helwan University. Egypt.

Correspondence to: Al-Shimaa A. Mostafa , Department of Ophthalmology Faculty of Medicine; Helwan University. Egypt.

Email:

shimaafarag2016@gmail.com

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Abstract:

Background: A prevalent age-related systemic condition called pseudo-exfoliation syndrome (PEX) has severe ocular symptoms like glaucoma and cataracts, **Aim:** In this study, people with pseudo-exfoliation syndrome (PEX), anterior segment optical coherence tomography (AS-OCT) was utilized to evaluate the anatomical features of the anterior lens capsule and iris. **Patients and Methods:** This study was designed as a case-control study at Benha University Hospital, using 20 eyes from 18 patients—2 patients with bilateral PEX and 16 patients with unilateral PEX—and 10 eyes from the normal control group. **Results:** The parameters between the new PEX group and the control group were examined and compared using patients with pupillary diameters ranging from 5.5 to 7 mm. Iris thickness (central, ciliary, and pupillary) was considerably lower in the PEX group. Compared to the control group, BCVA was significantly lower in the PEX group. **Conclusion:** Our study revealed significant increase thickness of central ALC in PEX group by 11% when compared to control group. Iris thickness (mid-peripheral iris stromal thickness, iris thickness at the papillary border, iris thickness at the ciliary border) all decreased (by 25%, 37%, 39%) in PEX group when compared to the control group. Iris thickness may be assessed before and after dilatation for more accurate evaluation of iris thickness of PEX.

Key Words: Anterior Segment; Optical Coherence Tomography; Lens Capsule; Pseudo-Exfoliation Syndrome

Introduction

A frequent age-related systemic condition called pseudo-exfoliation syndrome (PEX) has major ocular manifestations such glaucoma and cataracts. Up to 30% of adults over the age of 60 are affected by PEX [1].

The zonules connect to the lens capsule at the zonular layer. Close attachments are created when the collagen bundles of the zonules entangle with the collagen fiber lamellae of the capsule [2].

Ocular symptoms of (PEX) include small, white fibrillar deposits on the anterior lens capsule and pupillary border, among other anterior segment features. Less frequently, the deposits impact the zonules, ciliary processes, corneal endothelium, and irido-corneal angle [3].

Loss of pupillary ruff and trans-illumination problems due to pigmentation of the iris sphincter region. The Sampaolesi line, a wavy pigmented line, develops on the trabecular meshwork and anterior to Schwalbe's line when the pigment builds up there [4].

According to reports, open-angle glaucoma, cataracts, and phacodonesis were caused by the use of PEX materials in the eye's anterior portion [5].

The density of corneal endothelial cells was shown to decrease in direct proportion to the amount of PEX material deposited on the iris surface [6]. Pseudo-Exfoliation syndrome is 70% underdiagnosed in pseudophakic patients, which may have important management consequences [7].

In this study, anterior segment optical coherence tomography (AS-OCT) was used to assess the anatomical characteristics of the anterior lens capsule and iris in individuals with pseudo-exfoliation syndrome (PEX).

Patients and methods

This investigation was designed as a case-control study at the Benha University Hospital, using 20 eyes from 18 patients (2 patients with bilateral PEX and 16 patients with unilateral PEX) and 10 eyes from the normal control group from October 2021 to October 2022 (1 year).

***Ethical Approval*:** The candidate obtained the approval of the Institutional Review Board (IRB) in Faculty of Medicine Benha University. Written informed consent was obtained from each participant. Ethical committee approval number **(543)**.

***Inclusion criteria*:** Age >50 years, refractive error 5 diopter sphere, refractive error 2 diopter cylinder, and clinically obvious PEX material at the pupillary border or on the anterior lens capsule are the characteristics of patient group (Group A). Group B (the control group): Age: greater than 50 years old; no prior experience with intraocular surgery.

***Exclusion criteria*:** A history of systemic disease (diabetes, sarcoidosis, lymphoma), prior intraocular surgery, peripheral anterior synechiae visible on indentation, iris dystrophy or dyscoria, and indications of ocular inflammation (ciliary injection, cells,

flare, discharge) as well as eyes that are using anti-glaucoma medication, have an intraocular pressure of less than 21 mmHg, or take systemic drugs that may alter the pupillary reflex.

Methods

Each participant was subjected to the following: Full history taking including: personal, present, past and family history as well as other ocular diseases or operations.

Clinical examination: Ocular examination: Snellen chart visual acuity, autorefractometer refractive error, and best corrected visual acuity testing, slit lamp bio microscopy examination to anterior segment of the eye, intraocular pressure measurement using airpuff (Topcon, CT-80, made in Japan), fundus examination: Dilated eye examined by indirect ophthalmoscope, biometry and anterior segment Optical Coherence Tomography using Optovue model: Avanti scanner. Part number (P/N):500-50845-002. Voltage: 100/240 vacuum (VAC), frequency: 60/50 hertz (HZ), current:8.33/4.38 Ampere (A), axial resolution 5µm/pixel, scan time: 3seconds. Mass: 49.4 kilogram (Kg), working load (lift) 100Kg. Made in USA.

Technique: Patients were dilated using cyclopentolate 1 %, switch on the device, enter the patient Data (name, ID, age, date), mount the Anterior Segment Lens, adjust the chinrest until eye s leveled at the red mark, select (cornea line) for corneal thickness , pupil diameter, anterior lens capsule thickness or (cornea angel) for iris thickness , AC depth or (wide pachymetry) for pachymetry map of the cornea, move the camera towards the patient's eye and acquire images using the joystick button.

Statistical analysis: The data were tabulated and statistically analyzed using the MedCalC program software version 19.1, Microsoft Excel 2016, and the Statistical Package for Social Sciences SPSS. (IBM Corp. Released 2017. IBM SPSS Statistics for windows version 26 Armonk, NY: IBM Corp). The independent t-test was used for inferential analyses when there were two independent groups and parametric data for quantitative variables, while the Mann Whitney U was used when there were two independent groups and non-parametric data. The chi square test for independent groups was used for inferential analysis of qualitative data. *p*- values under 0.05 were used to determine significance, and values beyond this limit are not significant. The *p*-value is a statistical indicator of how likely it is that a study's findings were accidental.

Results

This case control study was conducted on 20 eyes of 18 patients with PEX syndrome and 10 eyes of normal subjects as a control group.

Table (1) shows clinical characteristics among PEX group. Most lesions were unilateral (80%) while two patients (20%) (4 eyes) had bilateral lesions. Most lesions were in anterior lens capsule (65%), 6 (30%) eyes had lesions in ALC and pupillary border while one case showed lesion in pupillary border.

Table (2) shows Slit-lamp findings among PEX group. 12 (60%) eyes had nuclear cataract, 6 (30%) eyes had cortical cataract

and two (10%) eyes posterior subcapsular cataract.

Table (3) compares the thickness of the anterior lens capsule between the studied groups. In the PEX group, the mean central ALC thickness was 53.05 13.28 m, compared to 42.10 7.91 m in the control group. When compared to the control group, the central ALC thickness was significantly thicker (11% thicker) in the PEX group *(p=0.024).* In the PEX group and control group, the mean paracentral ALC thickness was 65.20 14.16 m and 50.50 8.30 m, respectively. When compared to the control group, the PEX group's paracentral (temporal) ALC thickness increased significantly (14.7 percent thicker; *p*=0.005).

Table (4) shows comparison between the studied groups regarding iris thickness. The mean central iris thickness in PEX group was 391.85± 96.44 µm while, in control group was 466.50± 61.99µm. There was a significant decrease of central iris thickness (25% less) in PEX group when compared to control group (p = 0.035). The average iris thickness at the ciliary border was 339.28 mm in the PEX group and 448.20 mm in the control group, respectively. In comparison to the control group, the PEX group's iris thickness at the ciliary border was considerably smaller (39% less) (p = 0.001). In the PEX group and control group, the mean iris thickness at the pupillary border was 278.44 111.60 m and 413.33 63.47 m, respectively. When compared to the control group, the iris thickness at the pupillary border was 37% less thick in the PEX group (p=0.003).

The analyzed groups are compared in table (5) with relation to corneal epithelial thickness. There was no discernible difference in the two groups' median corneal epithelial thicknesses of 59.17 7.43 m and 53.23 3.87 m, respectively (p = 0.103).

To examine the characteristics and compare them between the new PEX group and the control group, patients with pupillary diameters between 5.5 and 7 mm were chosen. Iris thickness (central, ciliary, and pupillary) was considerably lower in the PEX group. Table (6) shows that the PEX group's BCVA was significantly lower than the control group.

Case 1

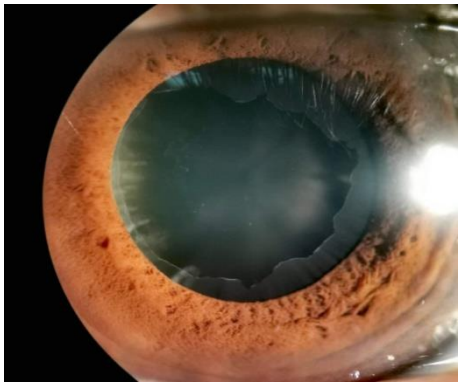

Figure 1: slit lamp photo of case 1

History: male patient, 65 years old, no diabetes or hypertension, no history of operations , history of RT eye trauma 2 months ago.

Chief complaint:

Bilateral diminution of vision.

Ocular examination:

Left eye:

UCVA: 0.1.

BCVA: 0.2.

Refraction: +4, -4 axis 75.

IOP 13 mmHg.

Slit lamp examination: anterior polar cataract, PEX.

Normal fundus.

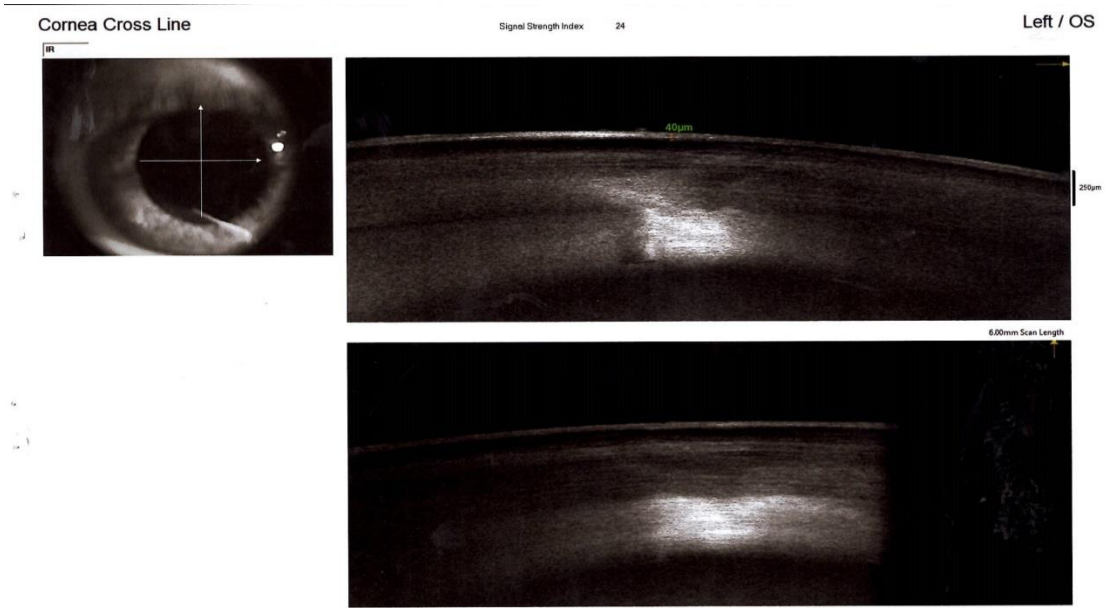

Figure 2: showing central ALC thickness of the case 40micron

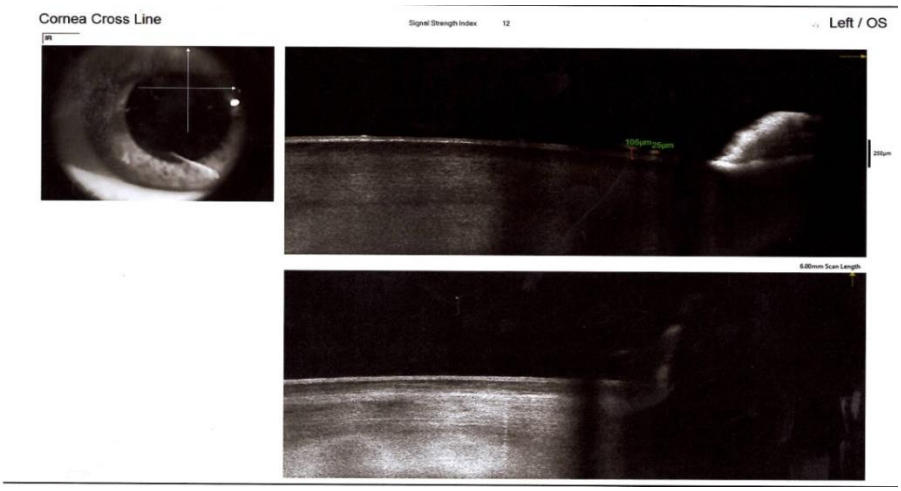

Figure 3: showing temporal ALC thickness by AS-OCT 105 micron

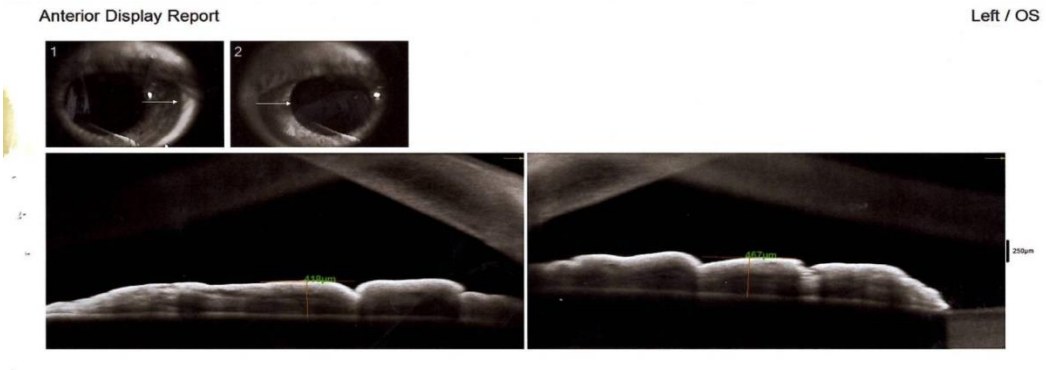

Figure 4: showing iris thickness by AS-OCT 418, 467 micron

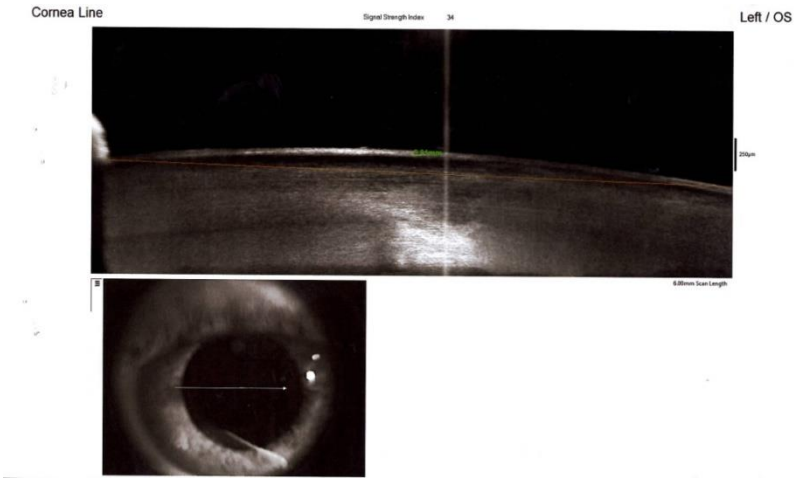

Figure 5: pupillary diameter by AS-OCT 6.81mm

Using AS-OCT

Central and temporal ALC thickness 40, 65 micron.

Temporal Iris thickness 418 micron.

Pupil diameter after pharmacological mydriasis 6.81mm.

Table (1): Clinical characteristics among PEX group (n=20)

		PEX group (No. = 20)	
		No.	**%**
Side of PEX.	**Unilateral**	16	80.0%
	Bilateral	2	20.0%
Site of PEX.	**ALC**	13	65.0%
	pupillary border	1	5.0%
	ALC and papillary border	6	30.0%

p≤0.05 is considered statistically significant; p≤0.01 is considered high statistically significant S.D.: standard deviation; ALC: anterior lens capsule; comparison between groups done by Chi- Square Test

Table (2): Slit-lamp findings among PEX group (n=20)

		PEX group (No. = 20)	
		No.	**%**
Slit-lamp findings	**Nuclear cataract**	12	60.0%
	Cortical cataract	6	30.0%
	Posterior subcapsular cataract	2	10.0%

p≤0.05 is considered statistically significant; p≤0.01 is considered high statistically significant; S.D.: standard deviation; ALC: anterior lens capsule; comparison between groups done by Chi- Square Test

Table (3): Comparison between the studied groups regarding anterior lens capsule thickn**ess**

Anterior lens capsule thickness		PEX group (No. = 20)	Control group (No. = 10)	% of change	Test of significance	*P-value*
Central ALC thickness *(µm)*	**Mean± S.D.**	53.05± 13.28	42.10± 7.91	11%	T= 2.391	**0.024**
	Median	51.50	40.50			
	Range	37.0 - 83.0	31.0 -61.0			
Temporal ALC thickness *(µm)*	**Mean± S.D.**	65.20± 14.16	50.50± 8.30	14.7%	T= 3.018	**0.005**
	Median	61.5	52.0			
	Range	40.0 - 92.0	40.0 -68.0			

p≤0.05 is considered statistically significant; p≤0.01 is considered high statistically significant; S.D.: standard deviation; comparison between groups done by Student T Test.

Table (4): Comparison between the studied groups regarding iris thickness

Iris thickness		PEX group (No. = 20)	Control group (No. = 10)	% of change	Test of significance	*P-value*
Central iris thickness *(µm)*	**Mean± SD**	391.85± 96.44	466.50± 61.99	25%	T= 2.219	**0.035**
	Median	384.50	452.0			
	Range	215.0 - 599.0	386.0 -587.0			
Iris thickness at ciliary border *(µm)*	**Mean± SD**	339.28± 77.37	448.20± 44.18	39%	T= 4.741	**<0.001**
	Median	340.0	462.50			
	Range	212.0 - 470.0	347.0 -494.0			
Iris thickness at pupillary border *(µm)*	**Mean± SD**	278.44± 111.60	413.33± 63.47	37%	T= 3.345	**0.003**
	Median	246.50	414.0			
	Range	129.0 - 600.0	291.0 -482.0			

p≤0.05 is considered statistically significant; *p≤0.01* is considered high statistically significant; S.D.: standard deviation; comparison between groups done by Student T Test.

Table (5): Comparison between the studied groups regarding corneal epithelial thickness

		PEX group (No. = 20)	Control group (No. = 10)	% of change	Test of significance	*P-value*
Corneal epithelial thickness *(µm)*	**Mean± SD**	59.17± 7.43	53.23± 3.87	2.9%	T= 0.370	0.103
	Median	60	52			
	Range	49.0 – 66.0	50.0 – 56.0			

p≤0.05 is considered statistically significant; p≤0.01 is considered high statistically significant; S.D.: standard deviation; comparison between groups done by Student T Test.

Table (6): Comparison between the studied groups regarding different parameters that pupillary diameter is 5.5–7 mm

		PEX group (No. = 20)		Control group (No. = 10)		% of change	Test of significance	P-value
		No.	**%**	**No.**	**%**			
Age (years)	**Mean± SD**	70.75± 3.65		62.20± 3.96		9%	T = 3.979	**0.002**
BCVA	**Mean± SD**	0.19± 0.18		0.86± 0.17		66.6%	T = 4.155	**<0.001**
Pupil diameter (mm)	**Mean± SD**	5.40± 0.47		6.56± 0.13		21.3%	T = 10.24	**<0.001**
Central iris thickness (µm)	**Mean± SD**	391.85± 96.44		466.50± 61.99		25%	T = 2.219	**0.035**
Iris thickness at ciliary border (µm)	**Mean± SD**	339.28± 77.37		448.20± 44.18		39%	T = 7.015	**<0.001**
Iris thickness at pupillary border (µm)	**Mean± SD**	278.44± 111.60		413.33± 63.47		37%	T = 5.366	**<0.001**
Central ALC thickness (µm)	**Mean± SD**	53.05± 13.28		42.10± 7.91		11%	T = 2.391	0.024
Temporal ALC thickness (µm)	**Mean± SD**	65.20± 14.16		50.50± 8.30		14.7%	T = 3.018	0.005
Corneal epithelial thickness (µm)	**Mean± SD**	59.17± 7.43		53.23± 3.87		2.9%	T = 0.370	0.103
AC depth (mm)	**Mean± SD**	2.77± 0.51		2.62± 0.25		0.03%	T = 0.567	0.577
Gender	**Male**	11	55.0%	8	80.0%		X^2= 4.232	0.070
	Female	9	45%	2	20.0%			

Discussion

The pseudo-exfoliation syndrome (PEX), which is characterized by debris that resembles dandruff on the lens and pupillary edges, was first identified by Lindeberg in 1917. PEX materials were shown to accumulate in visceral organs and ocular tissues [8].

The lens capsule varies in thickness, being thinner at the posterior pole (2–3 m) and thicker near the equator (21-23 m). [9].

In our study we measured the Anterior lens capsule (ALC) thickness in the central and paracentral regions using AS-OCT (OPTOVUE, spectral domain, with axial resolution 5µm/pixel made in USA, and we found out that mean ALC thickness was 53.05± 13.28 µm and 65.20± 14.16 µm, respectively in the PEX group and 42.10± 7.91 µm and 50.50± 8.30 µm, respectively in the control group with 11% increase of ALC thickness in the central region (*p*=0.024**)** and 14.7% increase in the paracentral region (*p*=0.005) (Table,3).

This is caused by the PEX material being deposited on the ALC and the pre-equatorial lens epithelium actively producing PEX material. In a study that used anterior segment OCT to evaluate the central ALC thickness, the researchers discovered that the mean central and temporal ALC thicknesses in the PEX group were respectively 21.64 3.01 m and 23.05 3.53 m and 18.43 m and 22.88 m in normal control patients. Additionally, there was no statistically significant difference between the two groups in the temporal region (*p* = 0.81), while the average thickness difference in the central region was 18% (3.4 m) (*p* = 0.0001) [3].

This agreed to our study regarding central ALC thickness and disagreed regarding Para central thickness which may be due to difference in the used device**.**

According to our research, the mean pupillary diameter in the PEX group following pharmaceutical mydriasis was 5.40 mm, while it was 6.56 mm in the control group. reduced by 21.3% in the PEX group (*p*= 0.001). In these patients, pseudo-exfoliative material buildup in the stroma and muscle tissues as well as degenerative alterations to the stroma, particularly the sphincter and dilator muscles, are connected to iris rigidity and inadequate mydriasis. The increase in pupillary diameter in the PEX group after pharmacologic mydriasis was 21% lower. This backed up our research [3].

Hypermetropes in the PEX group had primary position pupillary diameters that were significantly smaller (4.300.87 mm) than those in the control group (3.930.84 mm vs. 4.300.87 mm; *p*=0.03). [10]. A study evaluated the variations in pupil diameter between the PEX glaucoma, PEX, and control groups. The mean pupillary diameter in eyes with PEX glaucoma was smaller (4.830.82 mm) than in the PEX syndrome (5.201.10 mm) and control groups (5.421.12 mm). The distinction was not, however, statistically significant (*p*=0.15). Regarding to our studies, this is not true [11] as we found that the mid-peripheral iris thickness was 391.85±96.44 (25% lower) in the PEX group (*p*=0.035). Additionally, we measured

the thickness of the iris at the ciliary and pupillary borders. We found that the PEX group had an iris with a 39% lower mean ciliary border thickness 339.28±77.37 m (p=0.001) (Table, 4). Additionally, the pupillary border 278.44 ±111.60 m (p=0.003) showed a 37% drop in the PEX group. The anterior boundary layer, posterior pigment epithelium, dilator muscle, posterior pigment epithelium, stromal fibroblasts, melanocytes, sphincter muscle, and all other iris cell types could have contributed to the reduction in iris thickness. Additionally, endothelial, pericyte, and smooth muscle cells are deteriorating due to PEX fibers implanted in the adventitia of iris arteries. Midperipheral iris thickness was 36 7.2 m (7.8%) less in the PEX group following pharmacologic mydriasis (p = 0.047). This backed up our investigation [3].

A study measured iris thickness at the pupillary border using AS-OCT before pharmacological dilatation. Mean iris thickness of the PEX group was 1159 ± 519 µm and in the control group was 1484 ± 468 µm with significant decrease in the PEX group (p=0.018) [12].

We measured the corneal epithelial thickness using pachymetry map of AS-OCT. Mean corneal epithelial thickness was 59.17± 7.43µm in the PEX group and 53.23± 3.87 µm in the control group with (p = 0.103) (Table, 5) with no significant statistical difference between the 2 groups. A study compared corneal epithelial thickness in both PEX and control groups using AS-OCT. Mean corneal epithelial thickness in the PEX group was 31.44 ± 3.34 µm and in the control group was 37.35 ± 3.58 µm with significant decrease of corneal epithelial thickness in the PEX group (p = 0.001) [13].

In our study, the PEX group's AC depth is slightly higher. The mean AC depth in the PEX group was 2.77 mm, 0.51 mm in the control group, and 2.62 mm, 0.25 mm in the PEX group (*p=0.577*), indicating no statistically significant difference between the 2 groups. We evaluated AC depth following pharmacological dilatation in both groups, and this may be due to insufficient pupillary dilatation in the PEX group and complete dilation in the control group. A study measured AC depth in PEX group, PEX glaucoma and control groups using AS-OCT and found out that AC depth decreased in PEX and PEX glaucoma groups as compared to control group. This disagrees to our study [14].

A study revealed that mean ACD in the PEX group is 2.4941 mm and control group is 3.0728mm (p < 0.001) with significant decrease ACD in the PEX group [15].

Conclusion

Our study showed that the central ALC thickness considerably increased by 11% in the PEX group compared to the control group. The PEX group's post-dilatation pupil diameter dilation is 21.3% less than that of the control group. The iris thickness in the PEX group was greater than that in the control group (mid-peripheral iris stromal thickness, iris thickness at the papillary border, and iris thickness at the ciliary border) all decreased (by 25%, 37%, and 39% respectively). Iris thickness can be measured both before and after dilatation for a more precise assessment of PEX iris

thickness. An accurate non-invasive method for measuring ALC thickness is offered by AS-OCT. Additional research with a bigger sample size is required to exclude the effects of AC depth and corneal epithelial thickness in PEX patients and healthy controls.

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