

# Evaluation of anterior segment parameters in patients with pseudoexfoliation syndrome using Scheimpflug imaging

## Avaliação de parâmetros do segmento anterior por imagem Scheimpflug em pacientes com síndrome de pseudoexfoliação

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### ABSTRACT

**Purpose:** To evaluate anterior segment parameters in patients with pseudoexfoliation syndrome (PXS) using Scheimpflug imaging.

**Methods:** Forty-three PXS patients and 43 healthy control subjects were included in this cross-sectional study. All participants underwent a detailed ophthalmologic examination. Anterior segment parameters were measured using a Scheimpflug system.

**Results:** Considering the PXS and control groups, the mean corneal thicknesses at the apex point ( $536 \pm 31$  and  $560 \pm 31$   $\mu\text{m}$ , respectively,  $p=0.001$ ), at the center of the pupil ( $534 \pm 31$  and  $558 \pm 33$   $\mu\text{m}$ , respectively,  $p=0.001$ ), and at the thinnest point ( $528 \pm 30$  and  $546 \pm 27$   $\mu\text{m}$ , respectively,  $p=0.005$ ) were significantly thinner in PXS patients. Visual acuity was significantly lower ( $0.52 \pm 0.37$  versus  $0.88 \pm 0.23$ ,  $p<0.001$ ) and axial length was significantly longer ( $23.9 \pm 0.70$  mm versus  $23.2 \pm 0.90$  mm,  $p=0.001$ ) in the PXS eyes than in the control eyes. There were no statistically significant differences in the mean values of keratometry, anterior chamber angle, anterior chamber depth, corneal volume, and anterior chamber volume between the PXS and control eyes.

**Conclusions:** The patients with PXS had thinner corneas, worse visual acuity, and longer axial length compared with those in the healthy controls.

**Keywords:** Anterior eye segment; Exfoliation syndrome; Corneal topography; Cornea/anatomy and histology; Visual acuity

### RESUMO

**Objetivo:** Avaliar os parâmetros do segmento anterior em pacientes com síndrome de pseudoexfoliação (PXS) utilizando imagens de Scheimpflug.

**Métodos:** Quarenta e três pacientes com PXS e 43 indivíduos saudáveis foram incluídos neste estudo transversal. Todos os participantes foram submetidos ao exame oftalmológico detalhado. Parâmetros do segmento anterior foram medidos por sistema de Scheimpflug.

**Resultados:** Considerando os grupos PXS e controle, respectivamente, as espessuras médias da espessura corneana no ápice ( $536 \pm 31$   $\mu\text{m}$  e  $560 \pm 31$   $\mu\text{m}$ ,  $p=0,001$ ), no centro da pupila ( $534 \pm 31$   $\mu\text{m}$  e  $558 \pm 33$   $\mu\text{m}$ ,  $p=0,001$ ), e no ponto mais fino ( $528 \pm 30$   $\mu\text{m}$  e  $546 \pm 27$   $\mu\text{m}$ ,  $p=0,005$ ), foram significativamente mais finas em pacientes com PXS. A acuidade visual foi significativamente menor ( $0,52 \pm 0,37$  contra  $0,88 \pm 0,23$ ,  $p<0,001$ ) e comprimento axial foi significativamente maior ( $23,9 \pm 0,70$  milímetros contra  $23,2 \pm 0,90$  milímetros,  $p=0,001$ ) em olhos com PXS comparados com os olhos controle. Não houve diferenças estatisticamente significativas entre PXS e controle olhos em valores médios de ceratometria, ângulo da câmara anterior, profundidade da câmara anterior, volume da córnea e volume de câmara anterior.

**Conclusões:** Os pacientes com PXS tem córneas mais finas, pior acuidade visual, e maior comprimento axial em comparação com controles saudáveis.

**Descritores:** Segmento anterior do olho; Síndrome de exfoliação; Topografia da córnea; Córnea/anatomia & histologia; Acuidade visual

### INTRODUCTION

Pseudoexfoliation syndrome (PXS) is a common, age-related, systemic, extracellular matrix disorder characterized by the production and progressive accumulation of abnormal fibrillar extracellular material in intraocular and extraocular tissues<sup>(1)</sup>. The exfoliation material is produced by different intraocular cell types, such as lens epithelium, ciliary epithelium, iris, vascular endothelial cells, trabecular endothelium, basement membrane of the corneal epithelium, and corneal endothelium<sup>(1,2)</sup>. Tissue differentiation predisposes to several intraocular and surgical complications, including glaucoma, zonular dehiscence, phacodonesis and lens subluxation, capsular rupture or vitreous loss during cataract surgery, blood-aqueous barrier dysfunction, and corneal endothelial decompensation<sup>(3,4)</sup>.

In previous studies, the deposition of exfoliation material on the corneal endothelium, decreased endothelial cell density, changes of

the basal epithelium with the alterations of the subepithelial nerve plexus, decreased corneal sensation, and dry eye with the disturbances of the precorneal tear film have been reported<sup>(5-8)</sup>. However, there are conflicting studies about central corneal thickness (CCT) in patients with PXS or pseudoexfoliative glaucoma. Most studies have reported similar CCT in PXS and normal eyes<sup>(9-13)</sup>, but some authors have reported a thinner<sup>(14,15)</sup> or thicker<sup>(16,17)</sup> CCT in PXS eyes than in normal eyes.

The evaluation of anterior segment parameters is an important part of ophthalmic examination particularly for the assessment of endothelial function because of complications following cataract surgery and the risk of glaucoma in patients with PXS.

Therefore, the aim of the present study was to evaluate anterior segment parameters in patients with PXS by a comparison with those in healthy subjects.

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## METHODS

This cross-sectional study consecutively included 43 patients with PXS (27 men and 16 women) with a mean age of  $70.0 \pm 7.56$  years (range, 56-85 years) and 43 healthy control subjects (27 men and 16 women) with a mean age of  $67.3 \pm 10.0$  years (range, 52-85 years) from January 2014 to May 2015. The study was approved by the Institutional Ethics Committee and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all patients and controls.

After pupil dilation with 1% tropicamide, a diagnosis of PXS was made based on the presence of typical gray-white material on the anterior lens capsule (homogeneous central disc, intermediate clear zone, and peripheral granular zone), on the corneal endothelium, and at the pupil margin. Subjects with glaucoma [high intraocular pressure (IOP) (over 21 mmHg), glaucomatous optic nerve head changes, and glaucomatous visual field defects on computerized visual field examination], corneal disease, retinal disease, active ocular infection or inflammation, previous ocular surgery, ocular trauma, use of contact lenses, and refractive errors more than  $\pm 3$  diopters (D) were excluded from the study.

Control subjects were the patients admitted to the ophthalmology clinic for a routine examination without any complaints. However, subjects with a history of ocular disease and pathologic ocular findings were excluded from the study.

All of the participants underwent a complete ophthalmic examination, including refraction, best corrected visual acuity, IOP with Goldmann applanation tonometry, slit-lamp examination, fundus examination, and axial length measurement (PacScan 300AP+ biometric pachymeter; Sonomed, Lake Success, NY).

## EVALUATION OF ANTERIOR SEGMENT PARAMETERS

Anterior segment parameters were assessed using the Pentacam high-resolution rotating Scheimpflug imaging system (HR Pentacam; Oculus, Wetzlar, Germany). Measurements were performed with undilated pupils under scotopic conditions by the same ophthalmologist (A.G.). The automatic release mode was used, and unreasonable measurements were not evaluated and were marked in yellow and red on the monitor. The following parameters were extracted from the obtained topographic and pachymetric maps for statistical analysis: corneal power of the flat axis (K1), corneal power of the steep axis (K2), mean corneal power (Km), anterior chamber angle (ACA), anterior chamber depth (ACD), corneal volume (CV), anterior chamber volume (ACV), and corneal thickness at the apex point (regarded as CCT), the center of the pupil, and the thinnest point. Average values of three successful measurements were used for analysis.

## STATISTICAL ANALYSIS

Statistical analysis was performed using SPSS for Windows version 15.0 (SPSS Inc., Chicago, IL, USA). Only one eye of each participant was selected for statistical analysis. For patients with unilateral PXS, just the clinically involved eye was selected. In PXS patients affected bilaterally and control subjects, one of the eyes was randomly chosen. All data are reported as mean  $\pm$  standard deviation. Normality for continuous variables was determined by the Kolmogorov-Smirnov test. An independent-samples t-test was used for continuous variables with a normal distribution and the Mann-Whitney *U* test was used for continuous variables without a normal distribution to compare the means of two groups. Pearson and Spearman tests were used to detect the strength of the relationship between the variables. A *p*-value of  $<0.05$  was considered statistically significant.

## RESULTS

The demographic and clinical features of the patient and control groups are shown in table 1. There was no statistically significant

difference between the mean age of the PXS patients and that of the control subjects. The visual acuity was significantly lower and axial length was significantly longer in PXS eyes than in control eyes.

The mean values of K1, K2, Km, ACA, ACD, CV, ACV, and corneal thickness at the center of the pupil, the apex point (CCT), and the thinnest point are given in table 2. The mean corneal thicknesses at the center of the pupil ( $534 \pm 31$  versus  $558 \pm 33$   $\mu\text{m}$ ,  $p=0.001$ ), the apex point ( $536 \pm 31$  versus  $560 \pm 31$   $\mu\text{m}$ ,  $p=0.001$ ), and the thinnest point ( $528 \pm 30$  versus  $546 \pm 27$   $\mu\text{m}$ ,  $p=0.005$ ) were significantly thinner in the PXS patients than in the controls. There were no statistically significant differences between the patient and control group in K values or ACA, ACD, CV, or ACV values.

## DISCUSSION

PXS is an elastotic, age-related disorder characterized by the accumulation of abnormal extracellular matrix material in intraocular and extraocular tissues. In PXS patients, small, fluffy, white pseudoexfoliative materials are usually observed on the corneal endothelium, along with pigment deposition on the central corneal endothelium. This material can damage the corneal endothelium of PXS eyes and may lead to endothelial decompensation. It is known that a distinct form of corneal endotheliopathy occurs in patients with PXS. This special endotheliopathy can cause early corneal endothelial decompensation and may have been previously misdiagnosed as an atypical non-guttata Fuchs' endothelial dystrophy<sup>(8,18,19)</sup>. In addition, *in vivo* confocal microscopy studies have shown significant morphologic alterations in the corneas of PXS patients<sup>(5,20-22)</sup>.

**Table 1. Comparison of demographic and clinical data of PXS patients and controls**

	PXS patients (n=43)	Controls (n=43)	<i>p</i>
Age (years)	70.00 $\pm$ 7.56	67.30 $\pm$ 10.00	0.160
Sex (male)	27.00 (62.7%)	27 (62.7%)	1.000
BCVA (Snellen)	0.52 $\pm$ 0.37	0.88 $\pm$ 0.23	<0.001
IOP (mmHg)	16.00 $\pm$ 5.88	16.10 $\pm$ 3.20	0.900
AL (mm)	23.90 $\pm$ 0.70	23.20 $\pm$ 0.90	0.001

PXS= pseudoexfoliation syndrome; BCVA= best corrected visual acuity; IOP= intraocular pressure; AL= axial length.

**Table 2. Comparison of the anterior segment parameters of PXS patients and controls**

	PXS patients (n=43)	Controls (n=43)	<i>p</i>
Corneal power (front)			
K <sub>1</sub>	43.80 $\pm$ 1.57	43.2 $\pm$ 1.81	0.130
K <sub>2</sub>	44.50 $\pm$ 1.43	43.9 $\pm$ 1.72	0.070
K <sub>m</sub>	44.10 $\pm$ 1.48	43.5 $\pm$ 1.66	0.080
Pachymetric measurements ( $\mu\text{m}$ )			
Central	534 $\pm$ 31	558 $\pm$ 33	0.001
Apex	536 $\pm$ 31	560 $\pm$ 31	0.001
Thinnest	528 $\pm$ 30	546 $\pm$ 27	0.005
Corneal volume (mm <sup>3</sup> )			
ACA ( $^{\circ}$ )	30.30 $\pm$ 9.89	33.50 $\pm$ 9.66	0.110
ACD (mm)	2.71 $\pm$ 0.46	2.82 $\pm$ 0.77	0.790
ACV (mm <sup>3</sup> )	123.00 $\pm$ 23.40	132.00 $\pm$ 41.30	0.250

Data are indicated as mean  $\pm$  standard deviation. PXS= pseudoexfoliation syndrome; K1= corneal power of the flat axis; K2= corneal power of the steep axis; Km= mean corneal power; ACA= anterior chamber angle; ACD= anterior chamber depth; ACV= anterior chamber volume.

Corneal thickness is an important indicator of corneal health. Evaluation of corneal parameters is essential in the diagnosis and monitoring of glaucoma and when refractive surgery is scheduled. Currently, the Pentacam with Scheimpflug technology is used to assess corneal parameters in detail. This method provides evaluation of corneal pachymetry, anterior and posterior corneal topography, lens thickness, and anterior chamber depth, angle, and volume<sup>(23)</sup>.

Results reported in the literature have varied with respect to the CCT in pseudoexfoliative eyes. Arnarsson et al.<sup>(9)</sup> found that PXS was not associated with CCT. Rüfer et al.<sup>(24)</sup> determined that CCT was not significantly different among primary open-angle glaucoma, pseudoexfoliative glaucoma, and control groups, but patients with low-tension glaucoma had significantly lower CCT than that in the controls. Detorakis et al.<sup>(11)</sup> reported that differences in CCT between PXS eyes and age- and sex-matched controls were not statistically significant. Ventura et al.<sup>(12)</sup> and Yagci et al.<sup>(13)</sup> reported that there were no significant differences in CCT among normal-tension glaucoma, primary open-angle glaucoma, pseudoexfoliative glaucoma, and healthy control groups. However, Gorezis et al.<sup>(14)</sup> found that the CCT was significantly thinner in patients with pseudoexfoliative glaucoma. Similarly, Aghaian et al.<sup>(25)</sup> and Bechmann et al.<sup>(26)</sup> reported that the CCT was significantly lower in patients with pseudoexfoliative glaucoma, low-tension glaucoma, and primary open-angle glaucoma than in healthy individuals. Inoue et al.<sup>(15)</sup> examined the CCT and the endothelial morphology of the cornea in 26 eyes of 21 PXS patients (seven eyes with glaucoma and 19 eyes without glaucoma). The researchers represented that the corneal endothelial cell density and CCT were significantly lower in the PXS eyes than in the control eyes, but there were no significant differences in these factors between the PXS eyes in patients with and without glaucoma. Ozcura et al.<sup>(27)</sup> reported that CCT was significantly thinner in eyes with PXS than in control eyes, but was not thinner in the eyes of those with pseudoexfoliative glaucoma.

In the present study, the mean corneal thicknesses at the center of the pupil, the apex point, and the thinnest point were significantly thinner in the PXS patients than in the controls. We believe that the alterations of the corneal subepithelial nerve plexus, decreased corneal sensation, and dry eye with disturbances of the precorneal tear film may lead to corneal thinning as reported by Martone et al.<sup>(5)</sup> and Kozobolis et al.<sup>(7)</sup> The different results regarding corneal thickness in the literature might be because of racial differences, different methods, different sample sizes, and different age distributions in the sampled populations. Additionally, the PXS eyes had lower visual acuity and longer axial length than the healthy controls did in our study. These results are in agreement with a previous study reported by Jonas et al.<sup>(28)</sup>.

Doganay et al.<sup>(29)</sup> reported that there were no significant differences in ACV, ACA, CCT, and corneal volume values among patients with PXS, those with pseudoexfoliative glaucoma, and healthy controls. Similarly, there were no statistically significant differences between the patient and control groups in K values or ACA, ACD, CV, or ACV values in our study.

There are some limitations to this study in that it was a single-center study with a relatively small sample size. The anterior segment parameters need to be investigated in further large studies with different devices to understand these changes more clearly.

In conclusion, PXS patients had thinner corneas, lower visual acuity, and longer axial length than healthy controls did.

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