

# Anterior Segment Structures in Dark Iris Chinese Patients With Unilateral Fuchs' Uveitis Syndrome

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## Research Article

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# Abstract

**Purpose:** To compare binocular anterior segment structures in Chinese patients with dark iris and unilateral Fuchs' uveitis syndrome (FUS).

**Methods:** This was a cross-sectional study including 34 phakic eyes (17 patients) with unilateral FUS. Anterior segment parameters were measured by rotating Scheimpflug imaging camera, noncontact specular microscopy and anterior segment optical coherence tomography.

**Results:** Corneal volume was higher in FUS eyes compared to unaffected eyes ( $p < 0.05$ ). The iridocorneal angles were larger in FUS eyes compared to contralateral eyes ( $p < 0.05$ ). Mean endothelial cell density (ECD) was lower, and the coefficient of variation in endothelial cell size (CV) and average cell area of endothelial cells (ACA) were higher, in FUS eyes ( $p < 0.05$ ). Mean densitometry values of the midstromal cornea (zones with a diameter of 0-2, 2-6, or 10-12 mm), posterior (0-2, 2-6, 10-12, or 0-12 mm), or total thickness (0-2 or 2-6 mm) were higher in FUS eyes compared with unaffected eyes ( $p < 0.05$ ). ECD, CV, and ACA were negatively related to densitometry values of the midstromal and posterior cornea in the FUS eyes ( $p < 0.05$ ). Smoothness index of iris was larger in affected eyes ( $p < 0.05$ ).

**Conclusion:** In Chinese patients with unilateral FUS, loss of endothelial cells, wider iridocorneal angle, thicker cornea, higher corneal densitometry of midstromal and posterior layer, and smoother iris were observed in affected eyes compared to contralateral eyes. These data can help to elucidate anterior segment characteristics of unilateral FUS in this population.

## Introduction

Fuchs uveitis syndrome (FUS) is a chronic, typically unilateral, mild inflammatory disorder, which predominantly involves the anterior uvea [1]. It was first described by Ernst Fuchs in 1906 [2]. Characterized by fine stellate keratic precipitates (KPs), mild anterior chamber reaction, iris atrophic changes with or without heterochromia, vitreous involvement, and absence of macular edema or posterior synechiae [3–5], it affects both genders equally, occurring most frequently in the third and fourth decades of life [5–8]. It is also worth noting that heterochromia was more prominent in white patients with light colored eyes compared to those with dark or brown eyes [6]. As diagnosis is primarily based on clinical features versus laboratory examination, FUS is frequently incorrectly diagnosed, especially in patients with dark irises [9, 10]. Many studies have concentrated on identifying changes in anterior segment structures in eyes with FUS and have shown promising results contributing to accurate diagnosis [6, 11–18]. Currently, using advanced instruments, further details of the anterior segment disorders of FUS eyes are elucidated. Using Scheimpflug imaging, researchers identified corneal and anterior chamber characteristics in FUS eyes including corneal thickness, corneal densitometry values, iridocorneal angle, and iris bowing [12, 14]. Using anterior segment optical coherence tomography (AS-OCT), Zarei et al. [11] and Invernizzi et al. [19] described iris morphology alterations in FUS eyes by a “smoothness index” and iris thickness. Further, investigators have analyzed endothelial changes in eyes with FUS by specular

microscope [12, 14, 16, 18]. Simsek et al.[14] demonstrated the relationship between corneal densitometry and endothelial cell function. However, to our knowledge these anterior segment biometric parameters of FUS eyes in dark iris Chinese patients have not been reported. Yang et al.[6] reported on clinical features of Chinese patients with FUS by using auxiliary examinations including laser flare-cell photometry, ultrasound biomicroscopy (UBM), fundus fluorescein angiography (FFA), and serologic tests for *Toxoplasma gondii*. Yet, because Scheimpflug imaging, AS-OCT, and noncontact specular microscopy were not applied, subtle anterior segment biometric characteristics in this population were insufficient. To supplement the Chinese data, we measured corneal, iris, and anterior chamber parameters in unilateral FUS eyes by means of currently available advanced ophthalmic instruments.

## Patients And Methods

This cross-sectional comparative study was performed at Fujian Provincial Hospital between March 2020 and May 2021. The study followed the tenets of the Declaration of Helsinki and approval from the Institutional Ethics Board was obtained.

Thirty-four phakic eyes among 17 consecutive Chinese patients with unilateral FUS were enrolled. Diagnosis was made by one experienced ophthalmologist based primarily on clinical features, including stellate or round small to medium-sized KPs, chronic anterior uveitis, iris atrophy with or without heterochromia, absence of posterior synechiae, or absence of macular edema. Posterior subcapsular cataract, vitreous opacity, and secondary glaucoma are supportive for FUS, but are not essential for the diagnosis.

Patients with corneal abnormalities (opacities), intumescent cataract, a history of bilateral uveitis, bilateral FUS, any intraocular surgery, ocular trauma, or using medication that affects pupillary diameter were excluded from the study. Patients with previous elevated intraocular pressure (IOP) well-controlled with anti-glaucomatous agents were included.

A comprehensive ophthalmic examination was performed in both eyes of all patients including best corrected visual acuity (BCVA), slit-lamp biomicroscopy, IOP, and fundus examination. Corneal endothelial parameters were measured using Topcon Specular Microscope SP-3000 (Topcon Corporation, Tokyo, Japan). Anterior segment imaging was performed on each eye using a rotating Scheimpflug camera (Pentacam HR Oculus Optikger te GmbH, Germany) and AS-OCT scanning (Cirrus HD-OCT Model 5000, Carl Zeiss Meditec, Inc). All patients were examined in a sitting position by the same examiner who was masked to their eye disease status. Anterior segment images were obtained under the same brightness condition, e.g., Scheimpflug camera in dim-room lighting and AS-OCT in regular day room illumination.

Corneal and anterior segment biometric parameters were measured by Scheimpflug imaging including central corneal thickness (CCT), corneal volume, anterior chamber depth, anterior chamber volume, anterior chamber angles, undilated pupil size, anterior and posterior keratometric values (anterior K1, K2 and posterior K1, K2, respectively) and corneal densitometry. Corneal densitometry was analyzed by densitometry software, which automatically divided the cornea into four concentric zones (with diameters

of 2 mm, 2–6 mm, 6–10 mm, or 10–12 mm) and into three layers (120  $\mu\text{m}$  beneath the epithelium, 60  $\mu\text{m}$  above the endothelium, and the remaining middle layer). Only when being labeled as “OK” by the Examination Quality Indicator of the Pentacam were the images included and analyzed.

Images acquired from AS-OCT were used to calculate the iris smoothness index (SI). The iris was scanned horizontally on 3 o'clock and 9 o'clock position. If the examiner noted any artifact or images were blurred during scanning, the measurement was repeated until an acceptable image was achieved. The selected images were exported to and analyzed with ImageJ (ImageJ version 1.52, NIH, USA) software by one author who was masked to the affected eye. The Segmented Line tool and Strait Line tool of ImageJ were used to measure lengths with 300% magnification. SI was the ratio of length of the straight line connecting the most peripheral and the most central points of the anterior iris surface (nasal and temporal sides) to the actual length of this boundary (nasal and temporal sides) (Fig. 1) [11]. The overall SI was defined as the sum of length of nasal and temporal “straight lines” divided by the sum of nasal and temporal actual lengths of the anterior iris boundary [11].

## Statistical Analysis

Analyses were conducted using SPSS (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY). To describe data, we used mean, standard deviation, range, and percentage. Variables were investigated using the Shapiro-Wilk test to determine whether they were normally distributed. Comparisons were between two eyes of patients with unilateral FUS wherein the unaffected eye served as the control; therefore, paired sample t-test and Wilcoxon signed rank test analysis were used. Correlation coefficients' significance was calculated with the Pearson test. A p-value < 0.05 was considered statistically significant.

## Results

### *Demographic and clinical features*

This study included a total of 34 eyes among 17 participants (11 males, 6 females; aged 25–67 years) with unilateral FUS. The mean age was  $46.82 \pm 12.34$  years. Heterochromia was seen in 9 subjects. Posterior subcapsular cataract and glaucoma, respectively, were found in 2 (11.8%) and 15 (88.2%) FUS eyes. One subject with subcapsular cataract underwent uncomplicated phacoemulsification cataract surgery one week after study entry, during which Amsler-Verrey sign was observed. Previously, 15 affected eyes were treated with anti-glaucoma eye drops (beta blocker and/or carbonic anhydrase inhibitor) and short-term steroids were used if necessary. (Table 1)

### *Corneal and anterior segment biometric parameters*

Central corneal thickness, corneal volume, anterior and posterior keratometric values were recorded and compared between FUS eyes and unaffected eyes. The corneal volume was larger in FUS eyes than in unaffected eyes ( $59.60 \pm 3.42 \text{ mm}^3$  and  $58.84 \pm 3.20 \text{ mm}^3$ , respectively;  $p = 0.005$ ). Anterior chamber

depth and volume, undilated pupil size, and iridocorneal angles were also compared. The average iridocorneal angles was wider in FUS eyes than in contralateral eyes ( $38.10 \pm 5.41^\circ$  and  $36.01 \pm 4.77^\circ$ , respectively;  $p = 0.007$ ) (Table 2).

The mean densitometry values of the center (zones with a diameter of 0–2 mm, 2–6 mm, or 10–12 mm), posterior (0–2 mm, 2–6 mm, 10–12 mm, or 0–12 mm), and total thickness (0–2 mm or 2–6 mm) were significantly higher in FUS eyes compared with unaffected eyes ( $p < 0.05$ ). The mean densitometry values of the remaining zones showed no significant differences (Table 3).

### *Corneal endothelial cell parameters*

Mean endothelial cell density, mean values of coefficient of variation in cell size (polymegathism or CV), average cell area (ACA), and percentage of hexagonal cells (pleomorphism or HEX) were compared between FUS eyes and unaffected eyes. (Table 4). There were significantly strong correlations between densitometry values of some zones in the midstromal, posterior, and total corneal layer ECD, polymegathism, and ACA ( $p < 0.05$  and  $r > 0.50$  for the majority of these comparisons) (Table 5).

### *Smoothness index*

The mean SI values of temporal, nasal, and total iris, respectively, were higher in FUS eyes ( $0.909 \pm 0.061$ ,  $0.924 \pm 0.026$ , and  $0.916 \pm 0.040$ ) compared to contralateral eyes ( $0.876 \pm 0.063$ ,  $0.897 \pm 0.056$ , and  $0.885 \pm 0.054$ ). These differences were statistically significant ( $p = 0.035$ ,  $p = 0.044$ , and  $p = 0.004$ ).

## **Discussion**

In this study, we primarily applied advanced imaging techniques including Scheimpflug imaging and AS-OCT in dark iris Chinese patients with unilateral FUS to analyze the anterior segment morphology changes. These data can help to elucidate anterior segment characteristics of unilateral FUS in this population.

Previous studies described changes in CCT in FUS eyes and drew different conclusions. Szepessy et al. [12] found significantly thinner CCT in FUS eyes using Scheimpflug imaging with a 20- $\mu$ m difference between affected and unaffected eyes. Conversely, using the same imaging technology, Simsek et al. [14] reported that CCT was comparable between both eyes of unilateral FUS cases. The studies of Basarir et al. [13] (measured with ultrasonographic pachimetry) and Goker et al. [20] (device not known) also detected similar results. Consistently, there was no statistically significant difference in CCT between FUS eyes and unaffected eyes in our study. However, these studies did not compare corneal volume. Corneal volume may be a more meaningful measure than CCT to detect change in corneal thickness and to monitor corneal swelling [21–24]. What's more, according to Takács, Suzuki and co-investigators, change in corneal volume due to swelling after phacoemulsification persisted longer than that of CCT [21, 22]. In our research we found that corneal volume, centered on the vertex with a diameter of 10 mm, was significantly larger in FUS eyes. This result indicates that there was invisible corneal swelling in affected

eyes even though the cornea was "all clear" by slit-lamp examination. Given that a large proportion of our subjects had secondary glaucoma, we speculate that micro edema of the cornea might be due to repeatedly elevated IOP.

The corneal densitometry obtained through light backscattering measurements provide precise information about corneal transparency [25]. The density is expressed in gray scale unit (GSU) ranged from 0 to 100. Zero means no opacification of cornea (maximum transparency) and 100 means completely opaque cornea (no transparency). In our study, significantly increased corneal densitometry was observed in FUS eyes in midstromal zones (0–2, 2–6, or 10–12 mm), posterior zones (0–2, 2–6, 10–12, or 0–12 mm) and total thickness zones (0–2 or 2–6 mm) compared to unaffected eyes. Coincidentally, Simsek and colleagues [14] reported a significant elevation in densitometry values of midstromal zones (2–6 or 6–10 mm), posterior zones (all), and total thickness zones (2–6 or 6–10 mm) in eyes with FUS compared to unaffected eyes. This indicated that even though the cornea observed by slit-lamp is "clear" in FUS, actually the clarity of cornea is decreased. It is known that corneal clarity is maintained depending on intact corneal structure, a framework of collagen fibrils arranged in a special manner and a functional corneal endothelium [26]. Among them, the corneal endothelium plays an essential role in preserving stromal dehydration, thereby maximizing the fidelity of light passing through the cornea [26]. However, endothelial cell loss in FUS eyes have been widely reported [12, 14, 16, 18]. Our study also showed that ECD was significantly lower in affected eyes. CV and ACA, respectively, were significantly higher in FUS eyes compared to unaffected eyes. In addition, the densitometry values of center, posterior, and total layers with various diameters were confirmed as strongly related to ECD, CV, and ACA. Simsek and colleagues [14] reported similar results. Therefore, we hypothesize that chronic inflammation in the anterior segment and ocular hypertension in subjects with secondary glaucoma resulted in numerical loss and redistribution of endothelial cells, impairing the barrier function of the endothelial layer and contributing to a net influx of aqueous fluid into the cornea presenting as greater corneal densitometry in the stromal and posterior layers. Furthermore, Labbé et al. [17] reported large hyperreflective deposits corresponding to KPs on the endothelium of all FUS patients. Hashida et al. [27] also reported low/moderate reflectivity of KPs in FUS. In our study, all affected eyes presented with dispersive KPs to varying degrees (Fig. 2), which may lead to increased densitometry of posterior zones as well. Therefore, the "clear" cornea we observed in slit-lamp may be not truly transparent in FUS eyes which might affect the visual quality rather than visual acuity. Especially, in secondary glaucoma, the disorder of corneal clarity and endothelium needs more attention. Additionally, since cataract is an important complication of FUS, when consider the premium intraocular lens implantation, the possible impact of reduced corneal transparency on postoperative visual quality should also be considered.

The alteration of iris is a characteristic sign of FUS. Other than conventional slit-lamp biomicroscope, researchers also applied some more delicate and advanced approaches to observe and evaluate the iris change in FUS. In 1978, Melamed et al. [28] investigated the irises of two FUS patients by electron microscopy and described abnormal melanocytes with relatively few, small, and at times immature, melanin granules. However, this method is invasive and difficult to perform in vivo. Afterwards, using Scheimpflug imaging, Szepessy et al. [12] noninvasively observed that the iris shape had significantly

decreased its convexity in all FUS eyes, but iris cannot be quantitatively assessed. With the advent of AS-OCT, investigators who attempted to quantitatively document iris atrophic changes *in vivo* drew conflicting conclusions by measuring iris thickness [13, 18, 19]. Therefore, in these years, Zarei et al. [9] proposed using iris SI to quantitatively document diffuse smoothness of iris anterior surface. They pointed out that prior to the advent of OCT, when using the term “atrophy” to describe iris findings in FUS, ophthalmologists often referred to a decrease in surface features largely based on observations with slit lamp exam. They also considered SI was more precise and objective than iris heterochromia and iris thickness, which may potentially help in correctly diagnosing dubious cases. In our study, we analyzed overall SI, temporal SI, and nasal SI in affected and unaffected eyes using AS-OCT. The results demonstrated that the SI in temporal, nasal and overall iris was significantly greater in affected eyes, which was consistent with the result of Zarei et al. Comparing the outcomes of both studies, we found that temporal, nasal and overall SI measured by us was numerically greater than that of Zarei et al. either in affected eyes or unaffected eyes. We speculated that the difference of ethnicity could have a possible effect on the results. It’s noteworthy that the enrolled patients in their study were all Iranian while in our study were all Chinese. In addition, both investigations didn’t belong to large sample research, a larger sample size is needed to confirm this conjecture.

Using Visante OCT (anterior segment TD-OCT), Basarir et al.[13] found wider nasal, temporal iridocorneal angle and thinner iris in FUS eyes. They concluded that atrophy of iris and the trabecular meshwork plays a major role in widening of the angle. AS-OCT has the advantage of observing the precise structure of iris, however, neither Visante OCT nor Cirrus HD-OCT (anterior segment SD-OCT) used in our study can rapidly acquire the iridocorneal angle information in all directions due to inherent limitation. Therefore, Pentacam was simultaneously used in our study to estimate iridocorneal angle in 0- to 360-degree meridian through 3-dimensional anterior segment reconstruction. The result demonstrated that the average iridocorneal angle in affected eyes ( $38.10 \pm 5.41^\circ$ ) was larger than unaffected eyes ( $36.01 \pm 4.77^\circ$ ). Szepessy et al.[12] reported similar results when comparing binocular iridocorneal angle in the unilateral FUS patient by Pentacam. Because Pentacam cannot quantitatively measure the parameters of iris (e.g., iris thickness or SI), they only subjectively compared the shape of iris and supposed that the decreased convexity of iris caused widening of iridocorneal angle. In the current study, we not only used Pentacam to evaluate average iridocorneal angle, but used AS-OCT to precisely assess the change of iris by SI. Therefore, we had vigorous evidence to confirm that iris atrophy attribute to widening of iridocorneal angle.

The first limitation of our study is the small sample size; a larger future study of patients with unilateral FUS would substantiate validity. Second, we compared subjects' affected eyes with contralateral healthy eyes; the addition of a normal healthy control group would strengthen the study design.

In conclusion, we used contemporary technology including Scheimpflug imaging camera, noncontact specular microscopy, and AS-OCT to elucidate the anterior segment disorders in Chinese patients suffering from unilateral FUS. It appears that corneal volume is a more meaningful approach to characterize true corneal thickness changes, especially in the setting of transparent cornea by slit-lamp examination after repeatedly elevated IOP. Densitometry values could provide additional evidence for

corneal micro-swelling in these “clear” corneas and yield valuable information regarding corneal endothelial function along with ECD, AVA, polymegathism, and pleomorphism. In eyes without obvious heterochromia, SI and iridocorneal angle may provide additional insight for diagnosis, especially in dark or brown-colored eyes. Our findings supplement previous data of Chinese patients with unilateral FUS.

## Declarations

**Funding:** No funding was received for conducting this study.

**Conflicts of interest/Competing interests:** The authors declare that they have no conflict of interest.

**Availability of data and material:** The data generated during or/and analysed during the current study are available from the corresponding author.

**Code availability:** Not applicable.

**Authors' contributions:** Y.J Cai and W.J Wu contributed to the study conception and design. Y.J Cai, Y.B Wang and S.Z Xiao contributed to the acquisition of data. Y.J Cai and Y Huang performed data analysis and interpretation. Y.J Cai drafted the manuscript. W.J Wu contributed to manuscript revision. All authors contributed toward data analysis and critical review of the article. All authors read and approved the final manuscript and are responsible for its content.

**Ethics approval:** Ethics approval was obtained from Ethics Committee of Fujian Provincial Hospital.

**Consent to participate:** Patients provided written informed consent prior to undergoing any study procedure.

**Consent for publication:** Written informed consent included consent for publication of aggregated study results.

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## References

1. Sun Y, Ji Y. (2020) A literature review on Fuchs uveitis syndrome: An update. *Surv Ophthalmol* 65(2): 133-143. <https://doi.org/10.1016/j.survophthal.2019.10.003>
2. Fuchs E. (1906) *Über Komplikationen der Heterochromie*. *Z Augenheilk* 15: 191-212. 1906.
3. Gordon L. (2004) Fuch's heterochromic cyclitis: new clues regarding pathogenesis. *Am J Ophthalmol* 138(1): 133-4. <https://doi.org/10.1016/j.ajo.2004.03.031>
4. Jones NP. (1993) Fuchs' heterochromic uveitis: an update. *Surv Ophthalmol* 37(4): 253-72. [https://doi.org/10.1016/0039-6257\(93\)90009-v](https://doi.org/10.1016/0039-6257(93)90009-v)

5. Mohamed Q, Zamir E. (2005) Update on Fuchs' uveitis syndrome. *Curr Opin Ophthalmol* 16(6): 356-63. <https://doi.org/10.1097/01.icu.0000187056.29563.8d>
6. Yang P, Fang W, Jin H, Li B, Chen X, Kijlstra A. (2006) Clinical features of Chinese patients with Fuchs' syndrome. *Ophthalmology* 113(3): 473-80. <https://doi.org/10.1016/j.ophtha.2005.10.028>
7. Kreps EO, Derveaux T, De Keyser F, Kestelyn P. (2016) Fuchs' Uveitis Syndrome: No Longer a Syndrome. *Ocul Immunol Inflamm* 24(3): 348-57. <https://doi.org/10.3109/09273948.2015.1005239>
8. Bloch-Michel, E, Nussenblatt, R B. (1987 Feb 15) International Uveitis Study Group recommendations for the evaluation of intraocular inflammatory disease. *Am J Ophthalmol* 15 ;103(2):234-5. [https://doi.org/10.1016/s0002-9394\(14\)74235-7](https://doi.org/10.1016/s0002-9394(14)74235-7)
9. Zarei M, Ebrahimiadib N, Riazi-Esfahani H. (2019) Using anterior segment optical coherence tomography to compare the smoothness of anterior iris surface between two eyes in unilateral Fuchs' uveitis syndrome. *Graefes Arch Clin Exp Ophthalmol* 257(12): 2799-2800. <https://doi.org/10.1007/s00417-019-04477-x>
10. Zarei M, Darabeigi S, Mehrpour M, Roohipour R, Ghassemi H, Ebrahimiadib N. (2019) Fuchs' Uveitis in Iranian Patients: A Review of 89 Eyes. *Ocul Immunol Inflamm* 27(7): 1077-1085. <https://doi.org/10.1080/09273948.2018.1500612>
11. Zarei M, KhaliliPour E, Ebrahimiadib N, Riazi-Esfahani H. (2020 sept 23) Quantitative Analysis of the Iris Surface Smoothness by Anterior Segment Optical Coherence Tomography in Fuchs Uveitis. *Ocul Immunol Inflamm* : 1-6. <https://doi.org/10.1080/09273948.2020.1823424>
12. Szepessy Z, Tóth G, Barsi Á, Kránitz K, Nagy ZZ. (2016) Anterior Segment Characteristics of Fuchs Uveitis Syndrome. *Ocul Immunol Inflamm* 24(5): 594-8. <https://doi.org/10.3109/09273948.2015.1056810>
13. Basarir B, Altan C, Pinarci EY, Celik U, Satana B, Demirok A. (2013) Analysis of iris structure and iridocorneal angle parameters with anterior segment optical coherence tomography in Fuchs' uveitis syndrome. *Int Ophthalmol* 33(3): 245-50. <https://doi.org/10.1007/s10792-012-9680-8>
14. Simsek M, Cakar Ozdal P, Cankurtaran M, Ozdemir HB, Elgin U. (2021) Analysis of Corneal Densitometry and Endothelial Cell Function in Fuchs Uveitis Syndrome. *Eye Contact Lens* 47(4): 196-202. <https://doi.org/10.1097/ICL.0000000000000717>
15. Pillai CT, Dua HS, Azuara-Blanco A, Sarhan AR. (2000) Evaluation of corneal endothelium and keratic precipitates by specular microscopy in anterior uveitis. *Br J Ophthalmol* 84(12): 1367-71. <https://doi.org/10.1136/bjo.84.12.1367>
16. Mocan MC, Kadayifcilar S, Irkeç M. (2012) In vivo confocal microscopic evaluation of keratic precipitates and endothelial morphology in Fuchs' uveitis syndrome. *Eye (Lond)* 26(1): 119-25. <https://doi.org/10.1038/eye.2011.268>
17. Labbé A, Dupas B, Offret H, Baudouin C, Labetoulle M. (2009) Evaluation of keratic precipitates and corneal endothelium in Fuchs' heterochromic cyclitis by in vivo confocal microscopy. *Br J Ophthalmol* 93(5): 673-7. <https://doi.org/10.1136/bjo.2008.146100>

18. Ozer MD, Kebapci F, Batur M, Seven E, Tekin S. (2019) In vivo analysis and comparison of anterior segment structures of both eyes in unilateral Fuchs' uveitis syndrome. *Graefes Arch Clin Exp Ophthalmol* 257(7): 1489-1498. <https://doi.org/10.1136/bjo.2008.146100>
19. Invernizzi A, Cigada M, Savoldi L, Cavuto S, Fontana L, Cimino L. (2014) In vivo analysis of the iris thickness by spectral domain optical coherence tomography. *Br J Ophthalmol* 98(9): 1245-9. <https://doi.org/10.1136/bjophthalmol-2013-304481>
20. Goker YS, Ozdal PC, Erol YO, Kızıltoprak H, Karatepe MS. (2019) Evaluation of radial peripapillary capillary density in patients with Fuchs uveitis syndrome. *Graefes Arch Clin Exp Ophthalmol* 257(12): 2735-2742. <https://doi.org/10.1007/s00417-019-04491-z>
21. Takács AI, Kovács I, Miháلتz K, Filkorn T, Knorz MC, Nagy ZZ. (2012) Central corneal volume and endothelial cell count following femtosecond laser-assisted refractive cataract surgery compared to conventional phacoemulsification. *J Refract Surg* 28(6): 387-91. <https://doi.org/10.3928/1081597X-20120508-02>
22. Suzuki H, Takahashi H, Hori J, Hiraoka M, Igarashi T, Shiwa T. (2006) Phacoemulsification associated corneal damage evaluated by corneal volume. *Am J Ophthalmol* 142(3): 525-8. <https://doi.org/10.1016/j.ajo.2006.04.024>
23. Lam AK, Wong YZ, Cheng SY. (2011) Corneal volume measures for monitoring contact lens induced corneal swelling: a pilot study. *Clin Exp Optom* 94(1): 93-7. <https://doi.org/10.1111/j.1444-0938.2010.00517.x>
24. Doganay S, Bozgul Firat P, Emre S, Yologlu S. (2010) Evaluation of anterior segment parameter changes using the Pentacam after uneventful phacoemulsification. *Acta Ophthalmol* 88(5): 601-6. <https://doi.org/10.1111/j.1755-3768.2008.01446.x>
25. Otri, AM; Fares, U; Al-Aqaba, MA; Dua, HS (2012) Corneal Densitometry as an Indicator of Corneal Health. *Ophthalmology* 119 (3): 501-8. <https://doi.org/10.1016/j.ophtha.2011.08.024>
26. Eghrari AO, Riazuddin SA, Gottsch JD. (2015) Overview of the Cornea: Structure, Function, and Development. *Prog Mol Biol Transl Sci* 134: 7-23. <https://doi.org/10.1016/bs.pmbts.2015.04.001>
27. Hashida N, Asao K, Maruyama K, Nishida K. (2019 Oct) Cornea Findings of Spectral Domain Anterior Segment Optical Coherence Tomography in Uveitic Eyes of Various Etiologies. *Cornea*. 38(10):1299-1304. <https://doi.org/10.1097/ICO.0000000000002065>.
28. Melamed S, Lahav M, Sandbank U, Yassur Y, Ben-Sira I. (1978 Dec) Fuch's heterochromic iridocyclitis: an electron microscopic study of the iris. *Invest Ophthalmol Vis Sci* 17(12): 1193-9. PMID: 569136

## Tables

**Table 1** Demographic and clinical features of unilateral FUS patients

	Mean±SD (range)	Percentage (%)
Age (years)	46.8±12.34 (25-67)	
Gender (F/M)	11/6	65/36
Laterality (right/left)	7/10	41/59
BCVA (logMAR)		
FUS	0.22±0.49	
Unaffected eye	0.06±0.22	
Anterior segment signs		
KPs	17/17	100
Cell/flare aqueous	3/17	18
Iris depigmentation	9/17	53
Amsler-Verrey sign	1/17	6
Posterior subcapsular cataract	2/17	12
Vitreous opacity	3/17	18
IOP (mmHg)		
FUS	16.8±3.3	
Unaffected eye	17.4±2.7	

SD, standard deviation; F, female; M, male; BCVA, best-corrected visual acuity

**Table 2** Comparison of the anterior segment parameters between FUS eyes and contralateral eyes.

	FUS eye	Healthy eye	p Value
Central corneal thickness ( $\mu\text{m}$ )	538.80 $\pm$ 37.01	537.69 $\pm$ 35.84	0.787
Anterior keratometric value (K-1)	43.25 $\pm$ 1.24	43.13 $\pm$ 1.22	0.198
Anterior keratometric value (K-2)	43.95 $\pm$ 1.43	43.92 $\pm$ 1.38	0.768
Posterior keratometric value (K-1)	-6.16 $\pm$ 0.21	-6.14 $\pm$ 0.21	0.105
Posterior keratometric value (K-2)	-6.41 $\pm$ 0.18	-6.39 $\pm$ 0.20	0.198
Corneal volume ( $\text{mm}^3$ )	59.60 $\pm$ 3.42	58.84 $\pm$ 3.20	0.005*
Anterior chamber volume ( $\text{mm}^3$ )	162.13 $\pm$ 39.55	162.46 $\pm$ 37.09	0.927
Anterior chamber depth (mm)	2.89 $\pm$ 0.33	2.88 $\pm$ 0.32	0.565
Undilated pupil size (mm)	2.78 $\pm$ 0.43	2.60 $\pm$ 0.51	0.045*
Mean anterior chamber angle ( $^\circ$ )	38.10 $\pm$ 5.41	36.01 $\pm$ 4.77	0.007*

\* Statistically significant.

**Table 3** Corneal densitometry measurements of the patients with unilateral FUS.

	FUS eye	Healthy eye	p Value
Anterior (mm) (GSU)			
0-2	25.30±4.77	24.02±2.61	0.076
2-6	23.01±3.52	21.95±2.32	0.066
6-10	26.47±6.88	25.49±5.56	0.326
10-12	41.08±10.59	37.23±8.93	0.150
Total (0-12)	27.32±4.64	25.92±3.29	0.123
Center (mm) (GSU)			
0-2	16.18±5.44	14.50±0.85	0.012*
2-6	14.16±2.06	13.34±0.89	0.022*
6-10	18.02±4.75	17.36±4.08	0.423
10-12	25.04±4.25	22.37±3.77	0.034*
Total (0-12)	17.51±2.84	16.33±1.78	0.066
Posterior (mm) (GSU)			
0-2	15.52±3.71	14.02±0.93	0.002*
2-6	13.99±1.75	13.13±1.00	0.008*
6-10	17.55±3.39	16.93±3.10	0.073
10-12	21.78±3.27	20.25±1.94	0.044*
Total (0-12)	16.67±2.28	15.67±1.54	0.018*
Total thickness (mm) (GSU)			
0-2	19.00±4.53	17.50±1.25	0.001*
2-6	17.06±2.38	16.14±1.22	0.007*
6-10	20.68±4.87	19.92±4.10	0.381
10-12	29.29±5.54	26.62±4.61	0.067
Total (0-12)	20.51±3.15	19.30±2.07	0.058

GSU, Gray Scale Units, is the pixel luminance per unit volume in the Scheimpflug image.

\* Statistically significant.

**Table 4** Endothelial cell characteristics of the patients with unilateral FUS.

	FUS eye	Healthy eye	p Value
ECD (cell/mm <sup>2</sup> )	2320.2±329.0	2596.9±240.6	0.001*
CV (%)	35.4±6.8	30.6±3.5	0.004*
HEX (%)	56.6±9.9	60.2±10.5	0.258
ACA (μm <sup>2</sup> )	441.5±81.8	388.3±36.9	0.002*

ECD, endothelial cell density; CV (polymegathism), coefficient of variation in cell size; HEX (pleomorphism), percentage of hexagonal cells; ACA, average cell area

\* Statistically significant.

**Table 5** Correlation between the specular microscopy measurements and corneal densitometry values in affected eyes of the patients with FUS.

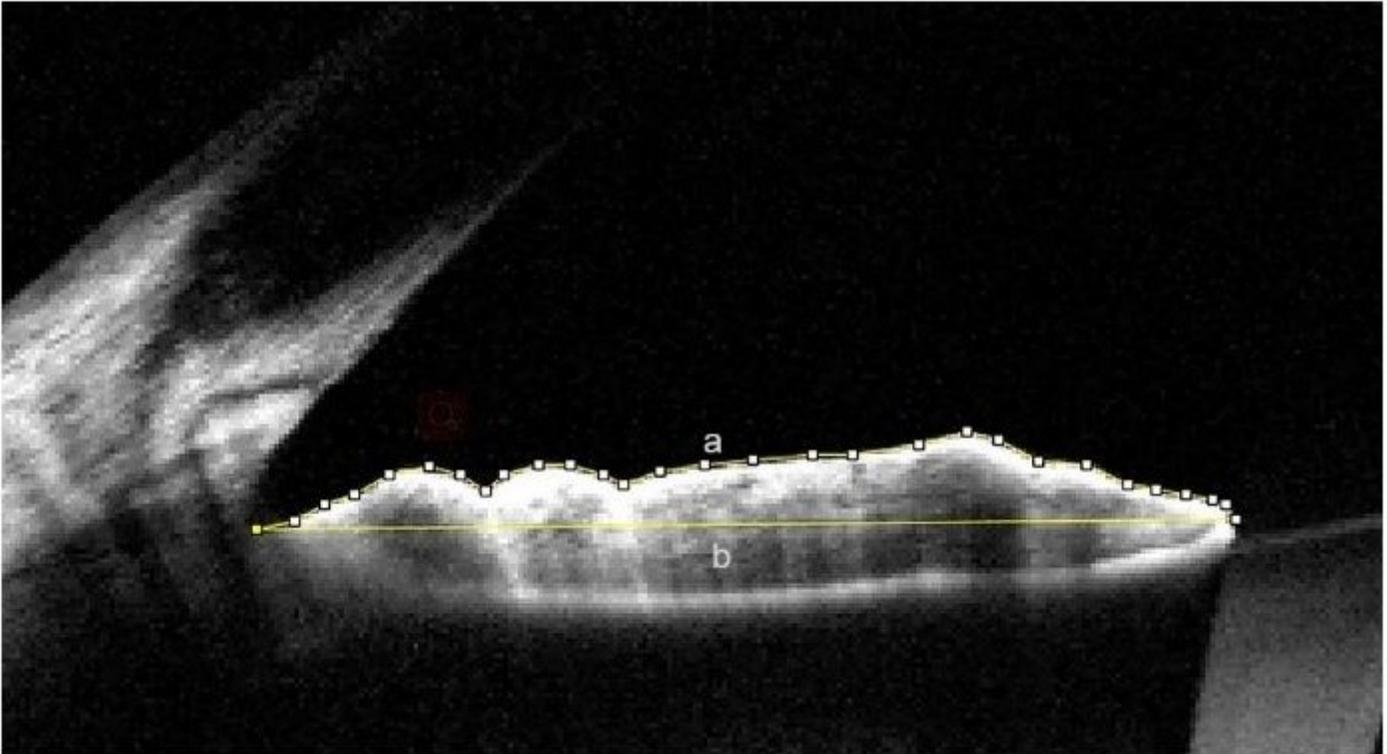
	ECD	HEX	ACA	CV
Center (mm)				
0-2	P=0.001*	P=0.023*	P<0.001*	P=0.487
	r=-0.716	r=0.546	r=0.862	
2-6	P=0.003*	P=0.012*	P<0.001*	P=0.519
	r=-0.677	r=0.592	r=0.796	
6-10	P=0.318	P=0.239	P=0.392	P=0.491
10-12	P=0.338	P=0.797	P=0.318	P=0.837
Total (0-12)	P=0.011*	P=0.040*	P=0.004*	P=0.993
	r=-0.600	r=0.501	r=0.657	
Posterior (mm)				
0-2	P=0.003*	P=0.045*	P<0.001*	P=0.631
	r=-0.672	r=0.492	r=0.822	
2-6	P=0.009*	P=0.066	P=0.001*	P=0.819
	r=-0.612		r=0.736	
6-10	P=0.346	P=0.682	P=0.374	P=0.244
10-12	P=0.186	P=0.799	P=0.131	P=0.913
Total (0-12)	P=0.030*	P=0.244	P=0.011*	P=0.759
	r=-0.526		r=0.601	
Total thickness (mm)				
0-2	P=0.003*	P=0.020*	P<0.001*	P=0.484
	r=-0.683	r=0.560	r=0.832	
2-6	P=0.007*	P=0.013*	P<0.001*	P=0.521
	r=-0.628	r=0.586	r=0.754	
6-10	P=0.241	P=0.344	P=0.255	P=0.578
10-12	P=0.352	P=0.912	P=0.382	P=0.911
Total (0-12)	P=0.024*	P=0.051	P=0.011*	P=0.999
	r=-0.542		r=0.602	

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\* Statistically significant.

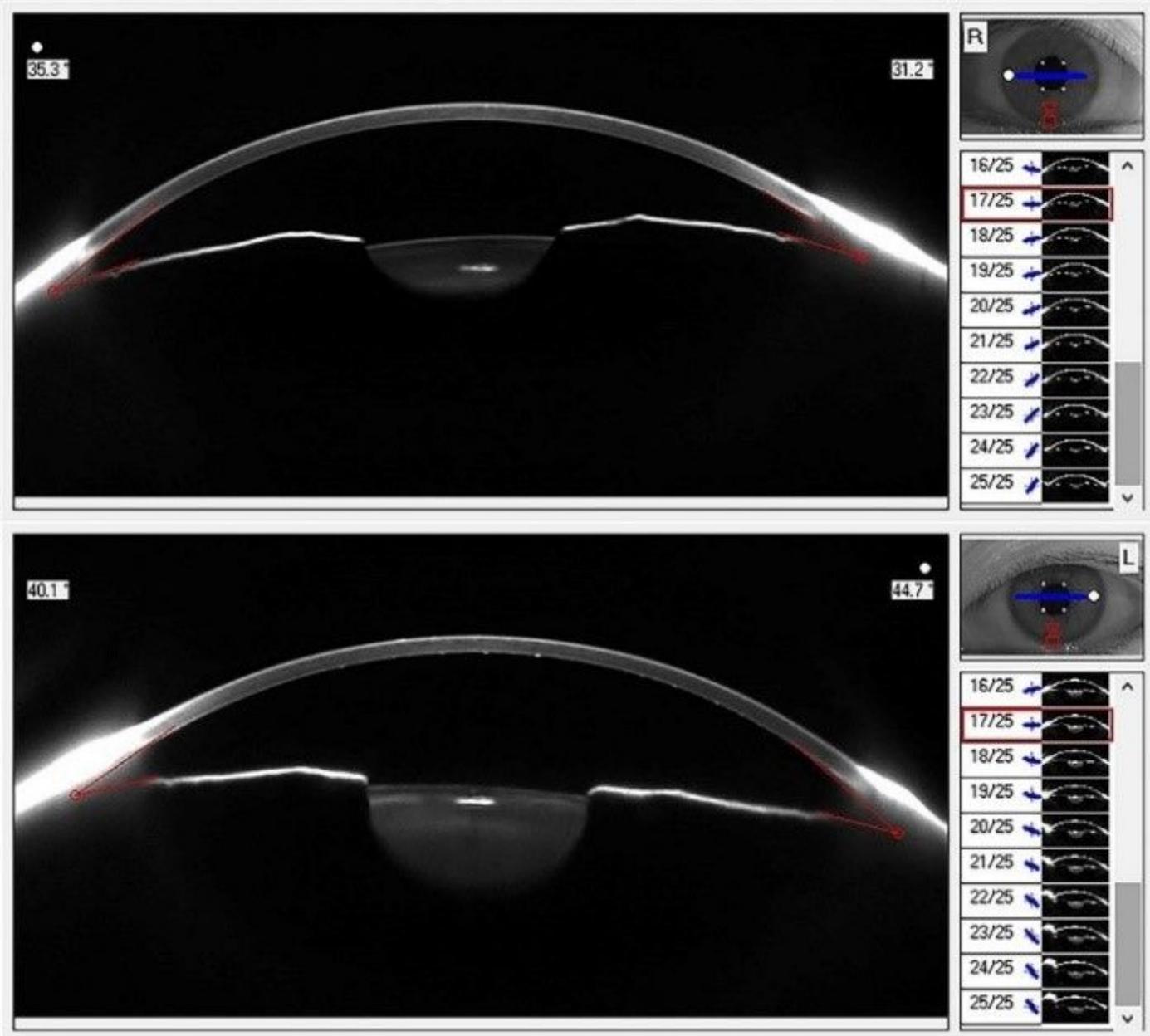
ECD, endothelial cell density; CV (polymegathism), coefficient of variation in cell size; HEX (pleomorphism), percentage of hexagonal cells; ACA, average cell area

## Figures



**Figure 1**

Smoothness Index (SI); ratio of the length of the straight line connecting the most peripheral and the most central points of anterior iris surface (b) to actual length of this boundary (a). Overall SI is the sum length of nasal and temporal “straight lines” divided by the sum of nasal and temporal actual lengths of anterior iris boundary.



**Figure 2**

Anterior segment image of a unilateral FUS patient. The many hyper-reflective points correspond to KPs on the inner surface of the cornea in the affected (left) eye. At the top is the unaffected eye and at the bottom is the FUS eye.