Original Article

How Does Pupil Size Affect Lens and Corneal Densitometry Measured by Scheimpflug Tomography?

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Abstract

Objectives: To investigate the effects of pupil diameter on the evaluation of lens and corneal densitometry measured by Scheimpflug tomography.

Materials and Methods: This cross-sectional and comparative study used the right eyes of 32 participants. Corneal and lenticular optical densitometries, corneal volume, anterior segment volume, and anterior chamber depth measurements were taken with the Scheimpflug imaging system when the pupils were mid-dilated and fully dilated. The results were statistically compared.

Results: The mean lens density was 19.20±3.05 when the pupils were mid-dilated (mean pupil diameter 2.98±0.89 mm) and 23.25±3.88 at full dilation (mean pupil diameter 5.01±0.92 mm) ($p<0.001$). The mean corneal density was 16.15±0.99 with mid-dilated pupils and 16.38±0.95 with fully dilated pupils ($p=0.065$). Anterior chamber depth and anterior segment volume measurements increased with larger pupil diameter ($p<0.05$).

Conclusion: The lens densitometry values increased with an increase in pupil diameter. The corneal density measurements increased minimally but the differences were not statistically significant. This study revealed that lens densitometry was significantly affected by pupil diameter.

Keywords: Lens, cornea, densitometry, light intensity, pupil size

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Introduction

Scheimpflug photography and densitometric image analysis are important techniques for biometric measurement of the anterior eye segments. These devices provide reliable data on anterior segment characteristics for clinical and experimental evaluation, enabling more precise examination of the effects of age, toxic substances, and diseases on the lens and cornea.[1] Thanks to the possibilities provided by this principle, many studies have been published investigating the impact of different diseases on corneal and lens clarity.[2,3]

The clarity of the cornea and lens can be assessed using Scheimpflug devices, which use imaging of an obliquely tilted object with the maximum depth of focus and minimum image distortion. However, it is well recognized that light intensity affects imaging, as with the Pentacam HR.[4,5]

In photography, the size of the lens aperture can be reduced or increased to allow more or less light to reach the camera sensor. A wide aperture gives a brighter image, while a narrow aperture yields a darker image.[6] As pupils work in a similar way, we think that the effect of pupil size on the amount of light transmitted may influence lens density measurements. By the same principle, corneal density measurements may be affected by the increase in the amount of light reflected back from the retina to the cornea as the pupil dilates.

The present study aimed to objectively examine how pupil size affects the evaluation of lens and corneal density using a Pentacam HR (Oculus Optikgeräte, GmbH, Wetzlar, Germany) Scheimpflug anterior segment imaging system.

Materials and Methods

This cross-sectional, comparative study included 32 participants, 12 women and 20 men. After a detailed explanation

of the aim of the study, informed consent was obtained from all participants. The study was approved by the Pamukkale University Non-interventional Clinical Research Ethics Committee (60116787-020/62680) and followed the tenets of the Declaration of Helsinki.

Study Population

The study included individuals over 60 years of age who had loss of lens accommodation, thereby ensuring mydriatic drops would not affect lens shape. All participants underwent ophthalmologic examination including visual acuity, biomicroscopy, and retinal examination. Participants with corneal disease, prior eye surgery, or severe trauma history were excluded. Only the participants' right eyes were included in the analysis.

Measurements and Study Procedure

Before data collection, 1% cyclopentolate hydrochloride drops (Sikloplejin; Abdi İbrahim Pharmaceuticals, İstanbul, Türkiye) were instilled according to standard methods. The measurement protocol described below was then performed twice, once when the participants' pupils were mid-dilated (10 minutes after the first instillation) and again when the pupils were fully dilated (30 minutes after the first instillation). As cyclopentolate reaches its maximum effectiveness after approximately 30 minutes, we made the full dilation measurements at this time.[7] Lens densitometry measurement is not possible when the pupil is non-dilated. Therefore, no measurement was made with non-dilated pupils. The participants' corneal volume, corneal density, anterior chamber depth, anterior segment volume, pupil diameter, and lens density measurements were evaluated using the Pentacam HR. All measurements were obtained in the same room and conditions. After positioning the head, participants were asked to fixate on the center of the blue slit light. The right eye of each participant was scanned three times by the same masked technician and the best quality image according to the Pentacam's examination quality specification was included. The 90- to 270-degree images were selected for assessment. The corneal stroma section from the central 6 mm cornea was selected for corneal densitometry. For lens densitometry, a 1.5 mm (vertical) x 3.0 mm (horizontal) rectangle was drawn in the region corresponding to the lens nucleus. These areas were selected for lens and corneal density measurements to ensure standardization. The Pentacam HR automatically calculated the corneal and lens densities. The Pentacam HR's screen for measuring lenticular and corneal densitometry is depicted in Figure 1.

Statistical Analysis

The statistical analysis was done with SPSS version 21.0 (IBM Corp., Armonk, NY, USA). The sample size was chosen by taking alpha: 0.05, beta: 0.20 and standard effect size: 0.70 in a t-test table. The variables were tested for normality using the Kolmogorov-Smirnov test. Paired-sample t-tests were used to compare measurements from the eyes when the pupils were mid-dilated versus fully dilated. P values less than 0.05 were considered statistically significant. Quantitative data were presented as mean ± standard deviation.

Results

The right eyes of 32 participants were assessed in this study. The mean age was 65.5±1.5 years. Table 1 shows the mean values for the subjects' anterior chamber depth, anterior segment volume, corneal volume, pupil diameter, and lens and corneal density measured at mid- and full dilation. With increasing pupil dilation, measures of lens density, anterior chamber depth, and anterior segment volume increased significantly ($p<0.05$).

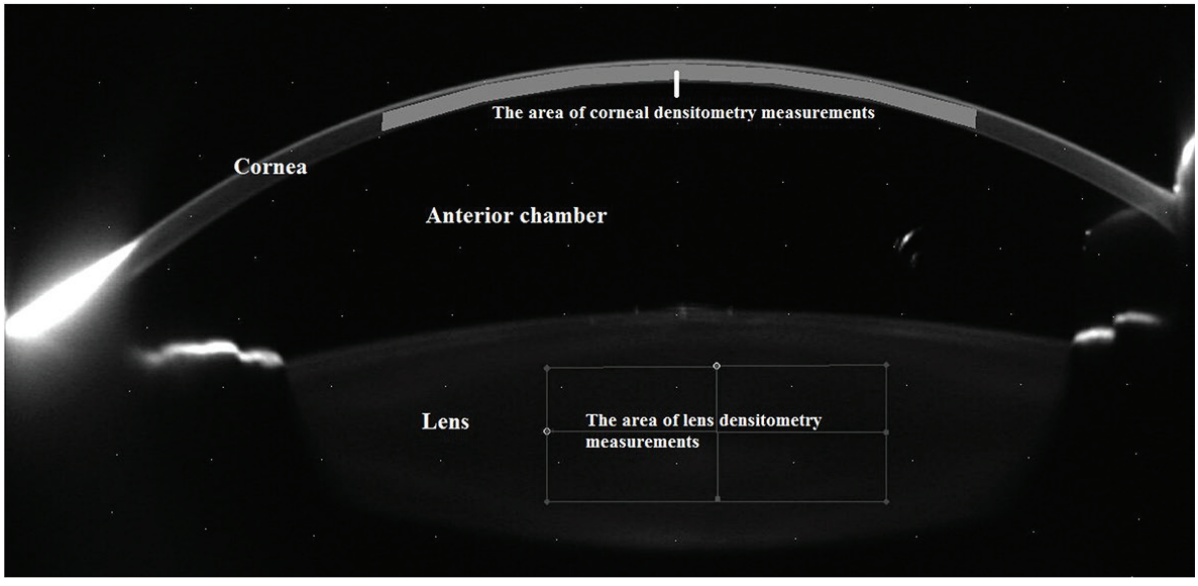

Figure 1. Areas of corneal and lenticular densitometric measurement

Table 1. Comparison of Pentacam measurements obtained with mid-dilated and fully dilated pupils

Measurements	Mid-dilated (10 min), mean ± SD	Fully dilated (30 min), mean ± SD	p value*
Anterior chamber depth (mm)	2.79±0.27	2.85±0.33	**<0.015**
Anterior segment volume (µL)	155.26±38.19	162.89±28.31	**0.006**
Corneal volume (mm^3)	59.22±2.98	59.33±3.52	0.39
Lens density	19.20±3.05	23.25±3.88	**<0.001**
Corneal density	16.15±0.99	16.38±0.95	**0.065**
Pupil diameter (mm)	2.98±0.89	5.01±0.92	**<0.001**

*Paired-samples t-test, SD: Standard deviation, Bold indicates statistical significance ($p<0.05$)

Discussion

The Pentacam is a non-contact Scheimpflug system for objective imaging of the anterior segment of the eyes. The Scheimpflug system is an optical imaging setup that enables the documentation of an obliquely tilted object with the maximum possible depth of focus and minimal image distortion. With a depth of focus extending from the anterior corneal surface to the posterior lens surface, this principle allows visualization of the entire anterior segment of the human eye. In particular, this technique has improved the accuracy and reproducibility of the assessment of lens and corneal clarity.[8] The method provides objective measurements to evaluate cataracts needing surgery. Cataract classification systems have been created to characterize the different stages of cataracts, guide surgical planning, and standardize cataract-related studies. Lens density measurement with the Scheimpflug principle may become the most important of these classification systems.[9,10,11,12] In addition, some factors such as drugs and radiation that affect lens transparency can also be evaluated with this method.[13,14]

The present study illustrated that pupil diameter affects lens densitometry measured by the Pentacam tomography system. However, the effect on corneal density was not significant.

Pupils function similarly to apertures in cameras and adjust the amount of light passing through the lens.[15] Previous studies have shown that increased light intensity causes an increase in lens and corneal densitometry measurements.[5] When the pupil diameter increases, the amount of transmitted light increases, so the lens densitometry value increases. Earlier lens density studies investigated different eyes under various conditions, but dilated eyes had different pupil diameters.[16] Even if measurements are performed on the same eyes, pupil diameters may vary because of instillation time.[17] Such factors reduce the reliability of these studies' results. Therefore, pupil diameter should be taken into account to make the measurements more accurate.

Extent of pupil dilation had no significant impact on the corneal density results. We thought that corneal density measurements might increase with the increase in pupil diameter due to the increase in the light reflected from the retina and reaching the cornea. However, a substantial portion of the light reaching the retina is absorbed. Increased pupil size may not have affected corneal densitometry because the light reflected back from the retina is too little to affect measurements.

Study Limitations

In this study, we compared measurements obtained from eyes at mid- and full dilation. However, "mid-dilated" and "fully dilated" are not concepts with a standard definition in millimeters. Moreover, the study does not include the correlation between pupil diameter and lens density values. Cyclopentolate is a mydriatic but also cycloplegic drop, which means it has an effect on the ciliary body and causes a change in lens shape. To avoid this effect, we selected presbyopic patients over the age of 60. Alternatively, the measurements could have been obtained with phenylephrine, a drop that has no effect on lens shape during pupil dilation.

Conclusion

The results of this study indicate that densitometric analyses of images can be influenced by pupil diameter. The potentially misleading effect of pupil diameter on the accuracy of density data increases the need for standardization in measurement.

Ethics

Ethics Committee Approval: Pamukkale University Medical Ethics Committee (60116787-020/62680).

Informed Consent: Obtained.

Peer-review: Externally peer reviewed.

Authorship Contributions

Surgical and Medical Practices: H.K., Concept: A.B., Design: A.B., Data Collection or Processing: H.K., Analysis or Interpretation: A.B., Literature Search: A.B., Writing: A.B.

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