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White to white cornea diameter and mesopic pupil size in patients with keratoconus

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Abstract

Objectives: Keratoconus is characterized by the abnormal cornea structure and it is manifested by changes in anterior segment parameters responsible for ocular high order spherical aberrations. The aim of the study is to investigate cornea horizontal white to white diameter and mesopic pupil size in patients with keratoconus.

Methods: The medical records of each participant were reviewed. The horizontal white to white cornea diameter and the mesopic pupil size were measured with the Sirius Topography System in 215 eyes of 123 subjects. Two groups were formed, the first group included 113 eyes with keratoconus and the second group is composed of 102 healthy eyes. Differences in sex, age, cornea diameter and mesopic pupil size between two groups were analyzed statistically.

Results: There were no statistically significant differences in sex and age distribution between the two groups (p>0.05). The average horizontal corneal diameter was 11.98±0.33 mm in the 1st group and 11.81±0.24 mm in group 2. It was significantly higher in patients with keratoconus than in healthy subjects. (p=0.04) The mean mesopic pupil size was 3.64±0.12 mm in group 1 and it was 3.73±0.14 mm in group 2. The mesopic pupil size was significantly higher in healthy subjects than in patients with keratoconus (p=0.03).

Conclusion: This study showed that while the horizontal white to white diameter of the cornea increases in keratoconus, the mesopic pupil size decreases. In clinical practice, these two parameters should be considered in treatment procedures of patients with keratoconus.

Keywords: cornea topography; horizontal cornea diameter; keratoconus; mesopic pupil size

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Introduction

Horizontal white-to-white corneal diameter or horizontal visible iris diameter (HVID) can be measured with various devices. Different methods ranging from simple measurements with a ruler to complex measurements with imaging devices led to varying normal values in study reports.[1,2] HVID is abnormal in some corneal diseases and glaucoma. Previously, HVID value assisted in determining macrocornea, microcornea, and screening glaucoma risk factors.[3] However, HVID has become essential in ophthalmic clinical practice, as it is critical to plan cataract and refractive surgery and calculate the power and diameter of phakic intraocular and contact lenses.[4,5] Pupil diameter should be checked for each patient. Pupil size is crucial because refractive corneal surgery, multifocal or toric contact lens wear, and intraocular multifocal lens implantation are completely personalized treatments.[6] Before refractive surgery, most surgeons plan the effective ablation zone considering the mesopic pupil size. The mesopic pupil size and effective optical zone on the cornea are incompatible. This incompatibility causes troublesome symptoms such as ghost images, blurred vision, and frequently, glare and haloes.[7] Previous studies have shown that mesopic pupil size is related to the dimensions of other ocular structures.[8] Mesopic pupil size may also have a relationship with corneal diameters.

Keratoconus is a progressive non-inflammatory problem diagnosed with corneal ectasia and thinning in the central zone.[9] The abnormal corneal structure that develops from keratectasia leads to irregular astigmatism and reduces the quality of vision.[10] Cornea topographic indices are critical for assessing the severity and development of keratoconus. There is an insidious progression in

keratoconus over time. The corneal topography system can easily detect this progression. However, further clinical information is required to validate this progression. For example, to the best of our knowledge there is no direct study in the literature on the measurement of mesopic pupil size in keratoconus patients. Nevertheless, varying pupil diameters may increase spherical aberrations in these patients.[11] HVID is critical in contact lens examination in keratoconus patients, yet there is no direct study on HVID.

To our knowledge, no study has researched the relationship between mesopic pupil size and HVID in some diseases. Therefore, the aim of the present study was to analyze the mesopic pupil size and HVID in patients with keratoconus.

Materials and Methods

This retrospective study took place at the Ophthalmology Department of a third-stage hospital following the ethical standards of the Declaration of Helsinki. The records of 123 subjects admitted to the Ophthalmology Department of Beyoğlu Eye Training and Research Hospital were retrospectively analyzed through the hospital's electronic database.

The medical records of each participant were reviewed. A comprehensive ophthalmologic examination included funduscopic examination, slit lamp biomicroscopy, and distant best corrected visual acuity (D-BCVA) testing were performed. Emmetropia was defined as the mean spherical equivalent between +0.75 and -0.75 diopter (D). For HVID and mesopic pupil size measurements, we used the Sirius system, a Placido-based videokeratoscope with two Scheimpflug cameras, one central and one rotating (Costruzione Strumenti Oftalmici, Scandicci, Italy).

The diagnosis of keratoconus was made clinically and considering the topography values. While there were newly diagnosed keratoconus patients in group 1 and no treatment was applied, there were healthy control subjects in group 2 whose age and sex distribution was compatible with group 1. Patients with a history of previous ocular or refractive surgery, ocular or systemic disease, or a history of ocular or systemic drugs that might affect pupil size were excluded. In addition, smokers and heavy alcohol drinkers (drinking five or more drinks on the same occasion on each of five or more days in the past 30 days) were also excluded.

The parameters of the study were also compared between the groups. The Kolmogorov-Smirnov test evaluated the distribution of the data. Chi-square test or paired sample t-test compared the data. The results for each parameter were in mean±standard deviation (SD). The Statistical Package for the Social Sciences version 20 (SPSS, Chicago, IL, USA) was used for data analysis. A value of $p<0.05$ was considered to be statistically significant.

Results

This study investigated the examination records of 215 eyes of 123 participants. There were 113 eyes in group 1 and 102 eyes in group 2. The ages were between 17 and 38, and the mean was 24.33±3.87. No statistically significant difference were present between the groups in the comparison of sex and mean age ($p>0.05$) (**Table 1**). Group 1 mean HVID was 11.98±0.33 mm, whereas group 2 mean HVID was 11.81±0.24 mm (**Figure 1**). The mean HVID was significantly higher in patients with keratoconus than in healthy subjects ($p=0.04$). In group 1, the mean mesopic pupil size was 3.64±0.12 mm, on the other hand the mean mesopic pupil size was 3.73±0.14 mm in group 2 (**Figure 2**). The mean mesopic pupil size was significantly higher in healthy subjects than in patients with keratoconus ($p=0.03$).

Discussion

HVID is the longest measurement from limbus to the opposite limbus in the horizontal plane. In normal pop-

Table 1
Demographics and clinical features of the study population.

Characteristic	Group 1 (mean±SD)	Group 2 (mean±SD)
Age (years)	23.13±4.27 (17–37)	24.88±5.05 (17–39)
Sex (% female)	%59.2	%56.3
Manifest spherical equivalent (D)	-6.89±1.10 D	-0.29±0.51 D
Cylinder (D)	-4.65±0.37 D	-0.24±0.18 D
HVID (mm)	11.98±0.33 (11.54–12.87)	11.81±0.24 (11.26–12.17)
Mesopic pupil size (mm)	3.64±0.12 (2.54–5.67)	3.73±0.14 (2.68–5.74)

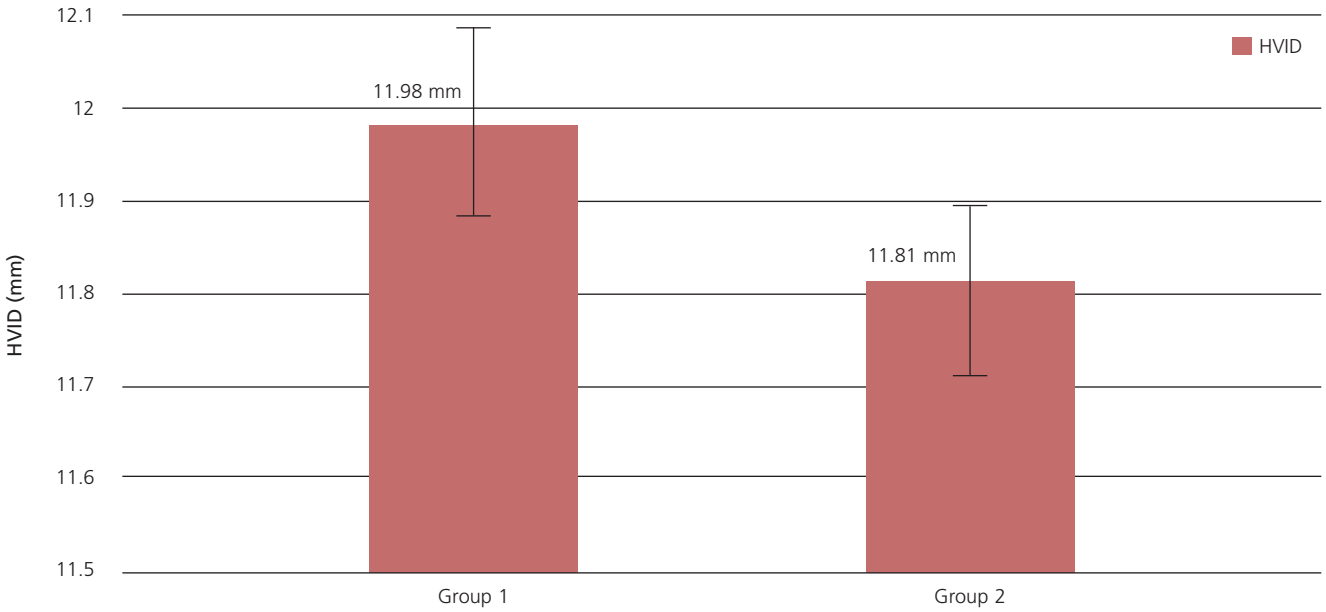

Figure 1. The mean HVID in the groups.

ulation studies, HVID was generally between 11.5 mm and 12.5 mm, and approximately 11.80 mm.[2,12] In our study, healthy control group subjects were close to these results, similar to the literature. Macrocornea is a corneal diameter greater than 12.5 mm, on the other hand, the definition of microcornea varies in horizontal diameters between less than 10.0 mm to 11.0 mm.[13,14] Seitz reported that large corneal diameters were present in keratoconus, lattice, and granular dystrophies, whereas smaller diameters were present in Fuchs` and macular corneal dystrophies.[15] Furthermore, different studies showed that age, sex, and height might affect this value.[2,16,17] In our study, healthy control group subjects and keratoconus patients showed a similar distribution in

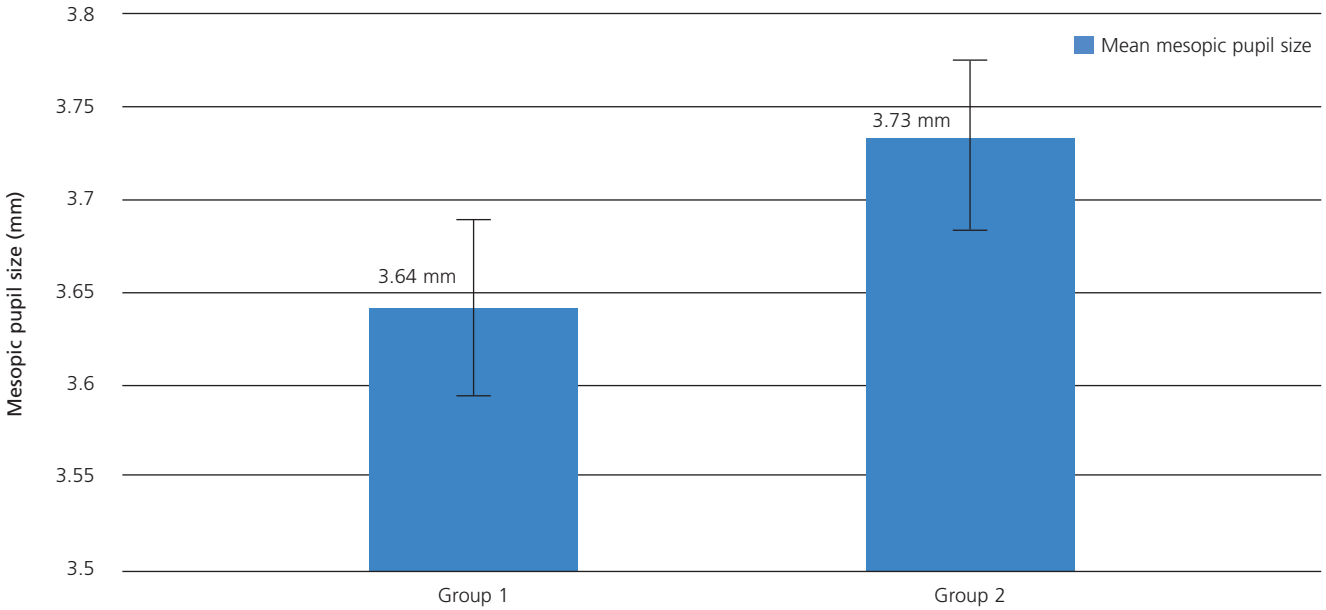

Figure 2. The mean mesopic pupil size in the groups.

age and sex. HVID was significantly higher in patients with keratoconus, and we were expecting such a result. However to the best of our knowledge no such study used HVID parameter of corneal topography in keratoconus patients before. There are increased in elasticity, keratometry values and anterior chamber depth in keratoconus compared to normal cornea. Perhaps, the increase in HVID may have occurred in parallel with the increase in corneal elasticity. HVID is a topographic measurement of clinical importance that must be considered when performing surgery with the indication of keratoplasty or when contact lens trials are performed on these patients and an appropriate lens prescription is created.Also increased HVID in these patients is a parameter that should be considered in the selection of suitable contact lenses and in the production of these lenses.

Pupil size is a valuable parameter with critical clinical implications.[18] Its measurement can help detect anomalies. Moreover, knowledge of its normal range is essential to the optical industry. Different normal values have been reported in various studies.[19,20] Because, mesopic pupil diameter is evaluated in a wide range from simple measurements with a ruler to complex measurements with devices using advanced imaging methods. Sanchis-Gimeno et al.[16] found the mesopic pupil diameter to be 3.6±0.4 mm ranged between 3 and 4.7 mm with radiological and anatomical measurements in their study on healthy large population individuals with a mean age of 29.2. Guillon et al.[21] found that the mesopic pupil diameter to be 3.82 mm on average in a healthy young population without refractive defects in their study using a dynamic pupillometer. In our study, the mean mesopic pupil diameter of the healthy control group was 3.74 mm. Mesopic pupil diameter values are generally affected by variables such as age, sex, refraction and device used for measurement.[22–24] Although the pupil diameter measurement results are contradictory in sex comparisons, values are generally close to each other.[25,26] Mesopic pupil diameter decreases with age.[27,28] We considered these two variables significant and selected the healthy control group as compatible with the keratoconus group in age and sex. To the best of our knowledge, there are no publications in the literature on mesopic pupil diameter measurements in keratoconus patients. The mesopic pupil diameter was significantly smaller in eyes with keratoconus compared to the healthy control group. High myopia and astigmatism values stand out in the eyes with keratoconus. In the literature, the mesopic pupil diameter tends to increase in myopic and astigmatic refraction defects.[22,29,30] It is curious to find that the mean mesopic pupil diameter decreases in the eyes with keratoconus while the pupil diameters increase in myopia and astigmatism. Spherical aberrations can become more complicated with increased pupil diameter and changes in anterior segment parameters. In their study, Hondur et al.[31] primarily revealed a greater pupillary offset in the eyes with keratoconus than the healthy controls, which was mostly in the superior direction (the positive y-offset). Mihaltz et al.[32] found that the pupillary offset due to mild to moderate keratoconus was evaluated with total ocular aberrometry, and a shift in the line of sight (LoS) was observed, which was interpreted as a compensating mechanism for increased corneal higher-order aberrations. Perhaps the reduction of the pupil diameter as a compensation mechanism may prevent spherical and chromatic aberrations in keratoconus patients.

Various comparative studies utilized different devices to measure anterior segment parameters.[33] In general, cornea topography devices have a very valuable place since they are easy to use and have good reproducibility in cornea and anterior segment measurements. The Sirius device we use has both two scheimpflug cameras and orb-scan topography. Thanks to the versatile operation of the device and the intelligent mapping system, the margin of error in the measurements have been minimized. Furthermore, the reliability of the measurements has been increased by successfully combining the anatomical and clinical parameters in the device. HVID was generally higher in keratoconus patients in our study, while mesopic pupil diameter tended to decrease. HVID is a significant parameter for selecting appropriate contact lenses in keratoconus patients.[34] In addition, it is a measurement that should be considered while preparing the donor cornea in patients who need keratoplasty.[35] Mesopic pupil diameter is also a parameter worthy of attention in using contact lenses and implantation of intraocular toric lens in these patients.[36]

One of the limitations of the study is its retrospective design. Since retrospective research may include several biases, such as information bias and selection bias, there may be some minor errors. Another limitation was the relatively small sample size. These results cannot be generalized to thousands of patients with keratoconus. Finally, because we conducted the study using patient records, we could not identify all predictive indices for keratoconus. Although this study employed two basic parameters, other parameters used in the keratoconus grading examination can be beneficial.

Conclusion

The present study has revealed the quantitative anatomy of the HVID and mesopic pupil diameter of patients with keratoconus and healthy emmetropic subjects. The results of the study showed that the HIVD is greater and the mesopic pupil size is smaller in patients with keratokonus. To our knowledge, this is the first study that analyzes the mesopic pupil size and HVID in keratoconus subjects.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

FÖ: manuscript writing/editing; TY: manuscript writing/editing; GG: protocol/project development, data analysis.

Ethics Approval

The study was approved by Ethical Committee of Prof. Dr. Cemil Taşçıoğlu City Hospital and carried out in accordance with the Helsinki declaration of principles.

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