

## A New Parameter in The Etiology of Hyperopic Anisometric Amblyopia: Corneal Densitometry

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### Keywords:

anisohipermetropic amblyopia, anterior segment parameters, cornea and lens densitometry, corneal topography, optical biometry

**Objectives.** To evaluate the anterior segment parameters and densitometric values of cornea and lens in children with anisohipermetropic amblyopia by corneal topography and optical biometry devices.

**Design.** Prospective cross sectional study.

**Participants.** Amblyopic and fellow eyes of 42 children with anisohipermetropic amblyopia (19 males, 23 females, mean age  $9.98 \pm 3.88$  years) and right eyes of 44 healthy children from pediatric outpatient (22 males, 22 females, mean age  $9.41 \pm 4.1$  years) were included in this study.

**Methods.** All patients were evaluated with sirius topography and optical biometry. Visual acuities, spherical refractive values, mean keratometric values, axial lengths, central corneal thickness, corneal volume, anterior chamber depth, anterior chamber volume, iridocorneal angle, pupil diameter, white to white, cornea densitometry and lens densitometry of amblyopic eyes, fellow eyes and healthy eyes were compared.

**Results.** Visual acuity was  $0.332 \pm 0.024$ ,  $0.0132 \pm 0.0058$ ,  $0.001$  (LogMAR) for amblyopic, fellow and healthy eyes respectively ( $p = 0.003$ ), spherical refractive  $3.79 \pm 2.52$ ,  $1.33 \pm 1.29$  and  $0.98 \pm 0.39$  respectively ( $p = 0.025$ ). ICA and central corneal densitometry were found lower in amblyopic eyes than in fellow and healthy eyes among sirius corneal topography parameters ( $p$  value 0.041, 0.001). There was no significant difference between groups in terms of optical biometry parameters except axial length.

**Conclusion.** In our study, we found that there were significant differences in iridocorneal angle, central corneal densitometry between groups. We think that it may be an important parameter in corneal density except for spherical equivalent and axial length in the etiology of hyperopic anisometric amblyopia.

Amblyopia is defined as a decrease in visual acuity resulting from abnormal binocular interaction, which can be improved with treatment during visual development, unilateral or bilateral visual acuity. In the researches, amblyopia was the most common cause of unilateral vision loss [1]. In the studies on the prevalence of amblyopia, rates ranging from 1% to 5.4% were found in different age groups [2-3] The study of the prevalence of amblyopia in Turkey, Eskişehir, Istanbul, Ankara and Southeastern Anatolia Region prevalence was found to be between 2.6% and 5.5% [4].

Strabismus, anisometropia, visual deprivation and uncorrected refraction defects are accused in the etiology of amblyopia [1-5]. In anisometric amblyopia, when there is more difference than 2 diopters (D) between the two eyes, amblyopia develops as a result of blurring of the retinal imagination in the eye with high refractive error, and suppression of the stimuli from the eye with shift in strabismic amblyopia. While clinical conditions such as congenital cataract, corneal opacity, complete ptosis and edema, inflammation, hemangioma, and closure of the eyelid cause

visual deprivation in deprivation amblyopia, amblyopia may develop as a result of failure of visual system if no optical correction is made in high grade refraction defects [5].

Although the pathophysiological mechanism of anisometric amblyopia cannot be fully explained, sensory discrepancy caused by the difference in the image in the retinal layer of both eyes is accused [5]. There is no other study in the literature in which the anterior segment parameters of anisohipermetropic cases in the amblyopia, fellow and healthy eyes were evaluated with corneal topography (especially cornea and lens densitometry) and optical biometry. In this respect, this study may be the first in the literature.

In this study, to investigate the anterior segment parameters and densitometric values of cornea and lens in children with anisohipermetropic amblyopia by corneal topography and optical biometry devices.

## Methods

This study is a prospective, cross-sectional study. In accordance with the Declaration of Helsinki and ethics approval was obtained from the local ethics committee with the number 80576354-050-99 / 43. Consent was obtained from the guardians of the participants included in this study. Amblyopic and fellow eyes of 42 children with anisohipermetropic amblyopia from ophthalmology department and right eyes of 44 healthy children from pediatrics department were evaluated by sirius topography and optical biometry.

Amblyopia criterion was accepted as the best corrected visual acuity of 0.8 or less with Snellen chart and at least 2 lines difference between both eyes. Anisometropia was defined as a cylindrical refraction difference of at least 1.00 D and above and a spherical refraction difference of 2 D and above between the two eyes. Spherical equivalent was calculated as the sum of the spherical value and half of the cylindrical value. Patients with visual acuity less than 1 according to LogMAR chart and who cannot fixate and children under five years of age who may have difficulty in adaptation to the devices, patients with organic pathology, nystagmus and a shift above 10 D, who have undergone eye surgery or corneal trauma was excluded.

Detailed ophthalmologic examination was performed in all cases included in our study. The best corrected visual acuity (BCVA) and the logarithmic responses of the minimum resolution angle (LogMAR) of these values were determined. Anterior segment and fundus examination findings were recorded in all cases. Refraction defects were determined by autorefractometer (Topcon KR-8100) 45 minutes after instillation of cyclopentolate hydrochloride 1% (Cycloplegine 1%, Abdi İbrahim Pharmaceutical Industry and Trade Inc.) The treatment of the amblyopic patients in our study was the application of glasses to correct the refraction error and the age-related patch (daily closure per hour equivalent to age).

Cycloplegic autorefractometry of all cases included in the study was measured by same person. Mean keratometry, corneal thickness map and central corneal thickness, anterior chamber depth, anterior chamber angle and corneal volumes, pupil diameter, densitometry of the center, 2 mm nasal and temporal sections of the cornea, central lens densitometry was measured with corneal topography device (Sirius, CSO, Florence, Italy). The Sirius corneal topography device is able to scan more than 30,000 points on the anterior and posterior surface of the cornea and the cornea and anterior chamber with 25 radial sections at the same time thanks to the 360° rotatable Scheimpflug camera system and the 22-ring plisido disc [6].

Axial lengths, central corneal thickness, anterior chamber depth, pupil diameter, white to white diameter were recorded by optical biometry. The Nidek AL-Scan optical biometry device (Nidek, Aichi, Japan) performs axial length measurement using partial coherence laser interferometry

technology. It calculates the refractive power of the cornea by detecting the straightest and steepest meridians with the help of photodetector by creating a ring image projection on the cornea of the patient [7].

Statistical analysis was performed with SPSS (Statistical Package for Scientific Studies, Windows version 21.0; SPSS Inc., Chicago, USA) 21.0 statistical package program with 95% confidence. While evaluating the study data, descriptive statistics; mean, standard deviation, median, frequency, ratio, minimum, maximum were used. Paired samples t and One-Way Anova test were used for the analysis of the quantitative data. Statistical significance was accepted as  $p < 0.05$ .

## Results

Forty-two children with anisohipermetropic amblyopia (19 males, 23 females, mean age  $9.98 \pm 3.88$  years) and 44 healthy children (22 males, 22 females, mean age  $9.41 \pm 4.1$  years) from pediatric outpatient were included in the study. There was no significant difference between the groups in terms of age and gender ( $p$  values 0.286, 0.195 respectively). Visual acuity, spherical and cylindrical refractive value, spherical equivalent were shown in table 1. All parameters were significant between the groups ( $p$  value 0.003, 0.025, 0.028, 0.001 respectively).

Sirius topography parameters for amblyopia, fellow and healthy eyes were shown in table 2. There was significant difference between the groups in terms of central corneal densitometry and ICA ( $p$  value 0.011, 0.041 respectively).

AL-Scan optical biometry parameters for the amblyopia, fellow and healthy eye were shown in table 3. There was no significant difference between the groups in terms of CCT, ACD, PD and WTW ( $p$  value 0.038, 0.101, 0.180, 0.93, 0.682 respectively), except AL ( $p = 0.038$ ). In 71.4% of amblyopic eyes, the axial length measured by optical biometry was shorter than the average of the axial length of the fellow and healthy eyes.

**Table 1.** BCVA, refractive error and spherical equivalent values of patients

	Amblyopic Eye	Fellow Eye	Healthy Eye	p ▼
BCVA (logMAR)	0.332*	0.0132	0.001	<b>0.003</b>
Spherical values (D)	3.79±2.52*	1.33±1.29#	0.97±0.65	<b>0.025</b>
Cylindrical values (D)	2.57±1.86*	0.99±1.04#	0.68±0.34	<b>0.028</b>
SE (D)	5.08±2.45*	1.83±1.47	1.55±0.96	<b>0.001</b>

BCVA – Best Corrected Visual Acuity; SE – Spherical equivalent; D – Dioptre; ▼ – One-Way Anova, \* – significant difference other groups, # – significant difference healthy eye

**Table 2.** Sirius corneal topography parameters by groups

	Amblyopic Eye	Fellow Eye	Healthy Eye	p ▼
K <sub>m</sub> (D)	43.11±1.57	43.21±1.57	43.01±1.57	0.834
CCT (µm)	545±40	542±34	540 ±36	0.837
CV (mm <sup>3</sup> )	57.6±3.5	57.4±5.7	57.0±5	0.987
ACD (mm)	3.11±0.31	3.11±0.30	3.13±0.30	0.882
ACV (mm <sup>3</sup> )	165.4±29.0	166.1±29.8	166.5±36.5	0.987
ICA (°)	45.6±5.4*	47.95±4.46	48.26±5.3	0.041
PD (mm)	4.38±1.57	4.31±1.53	4.04±0.98	0.467
CD (nasal)	17.49±1.75	18.12±3.79	17.9 ±1.65	0.528
CD (central)	21.38±1.55*	22.97±2.44	24.16±2.82	0.011
CD (temporal)	17.15±1.53	16.83±1.74	17.62±1.87	0.104
LD (central)	32.14±22.05	30.07±19.76	35.87±30.44	0.536

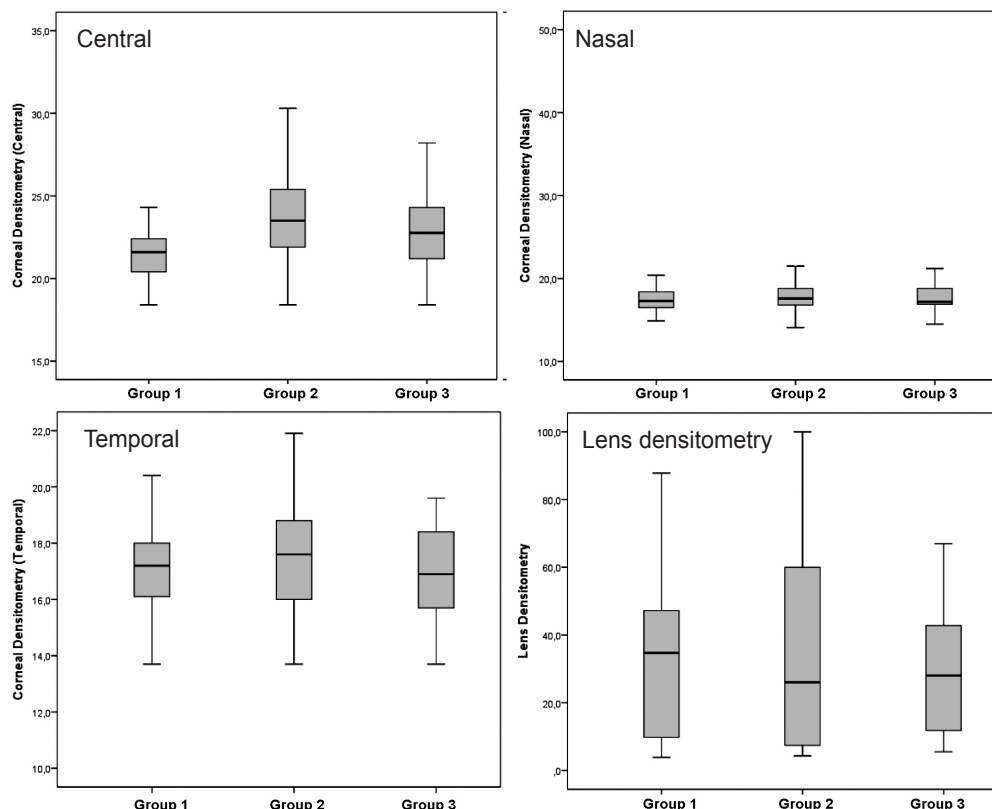
K<sub>m</sub> – mean keratometric values; CCT – central corneal thickness; CV – corneal volumes; ACD – anterior chamber depth; ACV – anterior chamber volume; ICA – iridocorneal angle; PD – pupil diameter; CD – corneal density; LD – lens density; ▼ – One-Way Anova, \* – significant difference other groups.

**Table 3.** Optical biometer parameters by groups

	Amblyopic Eye	Fellow Eye	Healthy Eye	p ▼
AL (mm)	20.80±1.45*	23.02±1.09	23.07±1.08	0.038
CCT (µm)	527.3±35	526.9±35	524.1±36	0.101
ACD (mm)	3.57±0.32	3.56±0.3	3.57±0.3	0.180
PD (mm)	5.81±1.52	5.82±1.46	5.46±1.57	0.93
WTW (mm)	12.17±0.36	12.16±0.41	12.07±0.44	0.682

AL – axial lengths; CCT – central corneal thickness; ACD – anterior chamber depth; PD – pupil diameter; WTW – white to white; ▼ – One-Way Anova, \* – significant difference other groups

**Figure 1.** Corneal densitometry (central, nasal and temporal) and lens densitometry according to groups



## Discussion

Amblyopia; it is used to describe the poor visual acuity caused by abnormal visual development during the critical period in childhood and is characterized by a loss of visual acuity ranging from not seeing a few letters in the range of 1.0 or 60/60 to hand movements. Uncorrected refractive errors in the pediatric age group may lead to amblyopia in contrast to adults. If the amblyopia developed in relation to the visual development process is not treated in early childhood, vision loss may be permanent and treatment in adulthood is not possible [8-9]. It is important to examine the factors that can cause this condition which cannot be treated in elderly. Therefore, the effect of anterior segment parameters was investigated in amblyopia patients.

Anisometropia is defined as a spherical difference of 2 D and above or a cylindrical difference of 1D and above between eyes [10]. It has been reported that 1D difference for spherical anisometropia and 1.5D difference for cylindrical anisometropia significantly increase the risk of amblyopia [11]. The difference in anisometropia up to 2.5D detected in infantile or early childhood decreases during the emmetropization process and does not cause amblyopia [12]. Therefore, anisometric refraction defects, especially after 4 years of age, carry a great risk for amblyopia and close follow-up of these cases is required. In this study, biometric and topographic parameters were investigated along with refractive changes causing anisometropia and the variables were tried to determine between the groups.

There was a significant difference between spheric, cylindrical and spherical equivalent values measured by autorefractometer between the groups. Axial lengths measured by optical biometry was found to be significantly shorter in amblyopic eyes. In 71.4% of amblyopic eyes, the axial length measured by optical biometry was shorter than the average of the axial length of the fellow and healthy eyes. This shows that the short axial length is the major risk factor in amblyopia in terms of biometric parameters. Axial hyperopia has been accused as the cause of amblyopia in anisometropia in several studies [13-14]. This study suggests that not only axial hyperopia, corneal spherical equivalent but also corneal densitometry may play a role in the etiology of anisohypermetropic amblyopia.

In our study, no significant difference was found between the groups in terms of mean keratometric, central corneal thickness, corneal volume, anterior chamber depth, anterior chamber volume, pupil diameter, temporal corneal density and lens density parameters measured by corneal topography. Wang et al. similar to this study, in hyperopic anisometric amblyopia, no significant difference was observed between amblyopia and healthy eyes in terms of anterior segment parameters [15]. Yüksel et al. evaluated the anterior segment parameters of children with amblyopia by pentacam and no significant difference was observed between these parameters [16]. However, these two studies do not provide information about corneal

and lens densitometry of children with amblyopia. In our study there was statistical significant difference between groups in respect of corneal densitometry. Also, spherical equivalent, axial length and iridocorneal angle were different between the groups. In the light of these findings, these may play a role in the etiology of amblyopia. Unlike this study, there are studies indicating that anterior chamber depth may be effective on amblyopia [17].

As far as is known, corneal and lens densitometry has not been investigated in the patients with amblyopia. In this respect, this study is the first in the literature. Corneal and lens density is an indicator of transparency. Lopes et al. reported that keratoconic corneas increased densitometry compared to normal corneas and increased density in advanced keratoconus in patients with keratoconus [18]. Ahmed et al. investigated corneal density for healing of patients with bacterial keratitis, reported that active infected infiltrates increased densitometry relative to the scar area of the cornea [19].

There are many studies on lens densitometry using Scheimpflug imaging [20]. It is stated that lens densitometry increases especially with age [21]. It has been reported that lens density increases with increasing degree of cataract, which decreases the optical quality of the eye [22]. However, a study about lens densitometry has not been found in the patients with amblyopia in the literature. In our study, there was no significant difference between lens densitometry values between the groups ( $p=0.536$ ).

In this study, axial length, central corneal thickness, anterior chamber depth, pupil diameter, white to white parameters were compared amblyopia, fellow and healthy eyes measured by optical biometry. There was no significant difference between the values except axial length. In the study of Huang et al. with the optical biometry device, the reproducibility and reliability of AL-Scan were excellent for all parameters except pupil diameter, white to white parameters [23]. It has shown that the results obtained from optical biometry data show excellent sensitivity and specificity to detect ametropic refractive risk [24]. In a study performed in myopic anisometric eyes, it was stated that there was no significant change in anterior segment parameters compared to the other eye [25]. In addition, in this study, no significant difference was found between the results of both devices in terms of central corneal thickness, anterior chamber depth and pupil diameter values. The fact that the results of both devices are close to each other indicates that the results are reliable.

Limitation of study: Comparison of hypermetropic amblyopic and non-amblyopic eyes in terms of ICA and corneal densitometry may show the strength of these parameters in amblyopia etiology.

## Conclusion

In this study, we found that there were significant differences in spherical equivalent, axial hyperopia, iridocorneal angle and central corneal densitometry between

groups. We think that it may be an important parameter in corneal density except for spherical equivalent and axial length in the etiology of hyperopic anisometropic amblyopia.

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*The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors did not receive any financial support from any public or private source.*

*Received 27.03.2020*