Black Sea Journal of Health Science
doi: 10.19127/bshealthscience.1090525

Open Access Journal
e-ISSN: 2619 – 9041

Research Article
Volume 5 - Issue 3: 387-394 / September 2022

EVALUATION OF CORNEAL AND LENS DENSITOMETRY WITH SCHEIMPFLUG IMAGING IN YOUNG BETA THALASSEMIA PATIENTS

Hafize Gökben ULUTAŞ[1]*, Elif Güler KAZANCI[2]

[1]*Bursa University of Health Sciences, Yuksek Ihtisas Training and Research Hospital, Department of Ophthalmology, 16310, Bursa, Türkiye*
[2]*Bursa University of Health Sciences, Yuksek Ihtisas Training and Research Hospital, Department of Pediatric Hematology, 16310, Bursa, Türkiye*

Abstract: The aim of this study is to compare corneal and lens density of children with Beta (β) thalassemia and healthy controls using Pentacam HR. This is a case-control and cross-sectional study. Anterior segment parameters, corneal, and lens densitometry of patients with β-thalassemia and healthy controls were evaluated with Scheimpflug corneal topography. For corneal densitometry analysis, the 12 mm diameter area of the cornea was divided into four concentric radial zones and anterior, central, and posterior layers according to corneal depth. The mean densitometry value for the crystalline lens was calculated in three regions around the center of the pupil. Non-contact specular microscopy was used to examine the morphology of the corneal endothelium. The study group consisted of 32 β-thalassemia major patients and the control group consisted of 31 healthy volunteers. The mean age of the study group was 12.12±3.94 years (range: 5-19 years) and 10.90±3.84 years (range: 5-19 years) in the control group (P>0.05). Corneal light backscattering in the posterior layer was significantly lower in the patient group than in the control group. Corneal endothelial cell density was determined as 3053.55±189.71 in the patient group and 3214±195.12 in the control group (P=0.094). Lens densitometry values did not differ between the two groups (P>0.05). We detected changes in corneal densitometry examination without any clinical findings in patients with β-thalassemia major. Pentacam may be a suitable screening technique for early detection of β-thalassemia ocular signs in children. Prospective studies with a large number of cases are needed to support these findings.

Keywords: Beta thalassemia, Corneal densitometry, Lens densitometry, Corneal endothelium

***Corresponding author:** Bursa University of Health Sciences, Yuksek Ihtisas Training and Research Hospital, Department of Ophthalmology, 16310, Bursa, Türkiye
E mail: gokbenbilekulutas@gmail.com (H. G. ULUTAŞ)
Hafize Gökben ULUTAŞ https://orcid.org/0000-0002-7961-3664
Elif Güler KAZANCI https://orcid.org/0000-0003-0910-1142

Received: March 20, 2022
Accepted: April 26, 2022
Published: September 01, 2022

Cite as: Ulutaş HG, Kazancı EG. 2022. Evaluation of corneal and lens densitometry with scheimpflug imaging in young beta thalassemia patients. BSJ Health Sci, 5(3): 387-394.

1. Introduction

Beta (β) thalassemia syndromes, one of the most common inherited blood disorders, are prevalent in Mediterranean countries, the Middle East, Central and Far East Asia, India, Southern China, and South America (Kadhim et al., 2017). The World Health Organization reported that thalassemia is common in 60 countries and affects the lives of approximately 10,000 people per year (Taneja et al., 2010). Hypochromic microcytic anemia occurs because of the defect in the synthesis of the beta globulin chain in the adult hemoglobin a structure (Demosthenous et al., 2019). In individuals with thalassemia major, they are diagnosed in the first years of life because of severe anemia and hepatosplenomegaly. With regular transfusion program and chelation therapies that reduce transfusion-induced iron overload, normal growth and development can be monitored and overall prognosis can be improved (Origa, 1993).

Regular blood transfusions are performed to treat chronic anemia in thalassemia patients. Continuous transfusion can cause iron overload in tissues, leading to organ dysfunction. Desferrioxamine, deferasirox, and deferiprone are used as iron chelating agents to prevent excessive iron accumulation in tissues (Jafari et al., 2015). Beta thalassemia major has systemic and ocular effects due to chronic anemia, iron accumulation in tissues as a result of erythrocyte destruction, use of chelation agents and blood transfusion (Taneja et al., 2010).

Ocular anomalies in thalassemia patients have been reported between 10.5% and 74%. This difference is due to the variable age in the patient groups, different treatment modalities, and the type of chelation drugs used. The most frequently reported ocular disorders are visual acuity loss, visual field defect, cataracts, retinal pigment epithelial degenerations, vascular tortuosity, and dry eye findings (Heydarian et al., 2020). In a study in iron-overloaded rats, hemosiderin accumulation was observed in interstitial tissue macrophages of ocular

tissues and lacrimal gland (Repanti et al., 2008).

Scheimpflug imaging system is used for morphological visualization of anterior segment parameters and measurement of ocular density of ocular tissues such as cornea and lens (Consejo et al., 2020). With this system, it is possible to evaluate changes in the lens before the development of clinically detected cataract.

A clear corneal tissue, which is necessary for a healthy visual acuity, depends on the regular collagen arrangement and the presence of healthy keratocytes. Corneal tissue is affected by many systemic diseases (e.g., endocrine disorders, inflammatory, infectious, and metabolic diseases) (Shah et al., 2021). In this study, it was aimed to compare corneal and lens density of young β-thalassemia patients and healthy controls using Pentacam HR device and to detect ocular disorders before clinical findings appear. To the best of our knowledge, this is the first study in the literature to evaluate lens and corneal density in patients with β-thalassemia.

2. Material and Methods

This case-control and cross-sectional study was performed from May 2021 to July 2021 at the department of ophthalmology and the department of paediatric haematology of a tertiary center. After explaining the purpose and content of the study to the children and their parents, written informed consent was obtained to participate in the study.

We included patients aged 5-19 years, who were diagnosed with β-thalassemia and regularly followed up and treated in the pediatric hematology clinic of the hospital. Hematological and electrophoretic tests were performed to diagnose β-thalassemia. In the hematological tests of the patients, it was observed that the hematocrit, erythrocyte count, and erythrocyte indices were low, and the HbA synthesis decreased (10-20%) and the HbF synthesis increased (80-90%) in the hemoglobin electrophoresis. All patients were receiving monthly blood transfusions and were using deferasirox and deferiprone as chelating agents. Patients' age at diagnosis, duration of disease, duration of chelating agent use, blood hemoglobin (Hb; g/dL) and ferritin (ng/mL) levels were recorded.

Patients were excluded from the study in the presence of the criteria listed below. 1) History of previous ocular surgery and trauma, 2) Best corrected visual acuity (BCVA) level less than 20/20, 3) Presence of ocular disease (e.g., cataract, glaucoma, ocular surface disorder), 4) Patients with spherical refractive error of more than three diopters, cylindrical refractive error of more than two diopters, 5) History of systemic or topical steroid use, 6) History of systemic disease other than β-thalassemia, 7) Patients unable to adapt for Scheimpflug imaging.

The control group consisted of age- and sex-matched healthy children who were consulted to the ophthalmology clinic for routine eye examination from the pediatric clinic. Complete ophthalmologic examinations of all patients were performed, including refractive measurement (RK-F2, Canon, Japan), best corrected visual acuity (BCVA), biomicroscopic examination, intraocular pressure (IOP) measurement (CT.1P, Topcon, Japan) and fundus examination. Non-contact specular microscopy (NSP-9900, Konan, Japan) was used to examine the morphology of the corneal endothelium. Three measurements were taken from the center of the cornea in each patient. At least 100 adjacent cells were analyzed by the automatic program. Specular microscopy automatically assessed endothelial cell density (ECD), the coefficient of variation (CoV), and percent cell hexagonality (Hex).

2.1. Scheimpflug Imaging of the Cornea and Lens

All participants underwent topographic and densitometric analyses through a rotating Scheimpflug camera (Pentacam HR, Oculus Optikgeräte GmbH). Measurements were performed by a single experienced user in the same clinical evaluation room. A black shield designed by the company was used to provide ambient darkness. All measurements were performed at the same time interval of day (between 12 and 13) to minimize the effect of diurnal changes in corneal hydration. Patients were instructed to blink twice just before measurement and then to keep their eyes open during measurement. Automatically triggered Scheimpflug scans (25 images in 2 sec) were performed for analysis. Acquisitions that the device's software quality control rated "OK" were used. The highest quality measurement data from the right eye of the participants were recorded. After the first Scheimpflug imaging, two drops of 1% tropicamide were instilled at five-minute intervals for pupil dilation. The second imaging was taken 45 minutes after the second drop of tropicamide for crystalline lens densitometry measurements.

Corneal densitometry with backscattering of corneal light on the standard Scheimpflug densitometry scale, it is expressed in grayscale units (GSUs). The measurements ranged from 0 (minimum dispersion and maximum transparency) to 100 (maximum dispersion and minimum transparency). The entire corneal area was divided into 4 zones. Zone 1 is the area with a diameter of 2 mm from the center of the cornea. Zone 2, 2-6 mm diameter annular area around zone 1. Zone 3, 6-10 mm diameter annular area around zone 2. Zone 4, 10-12 mm diameter annular area around Zone 3. Densitometry analyzes in all zones were performed at 3 different depths of the cornea. The anterior layer was 120 microns deep from the corneal surface, the posterior layer was at 60 microns of the inner most cornea, and the central layer was the area between the two layers (Figure 1).

Three-dimensional scanning modes were used for crystalline lens density measurement. The mean densitometry value for the crystalline lens was calculated in three regions around the center of the pupil. Pentacam Densitometry of Zone 1(PDZ1), 2.0 mm around. Pentacam Densitometry of Zone 2 (PDZ2) 4.0 mm

around. Pentacam Densitometry of Zone 3 (PDZ3) 6.0 mm around.

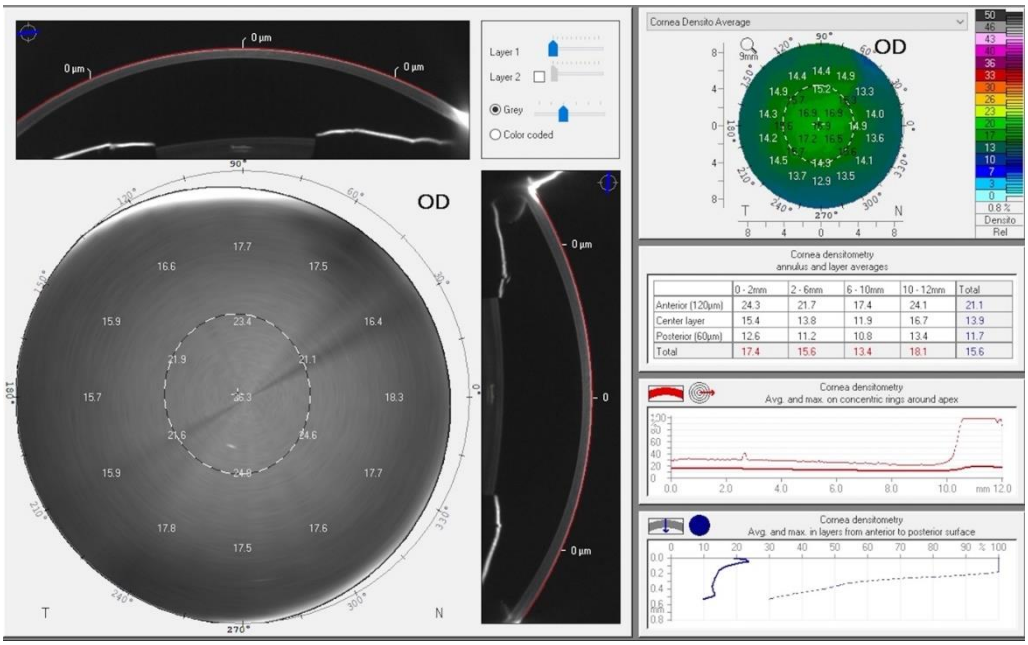

Figure 1. Scheimpflug tomography images and corneal densitometry values.

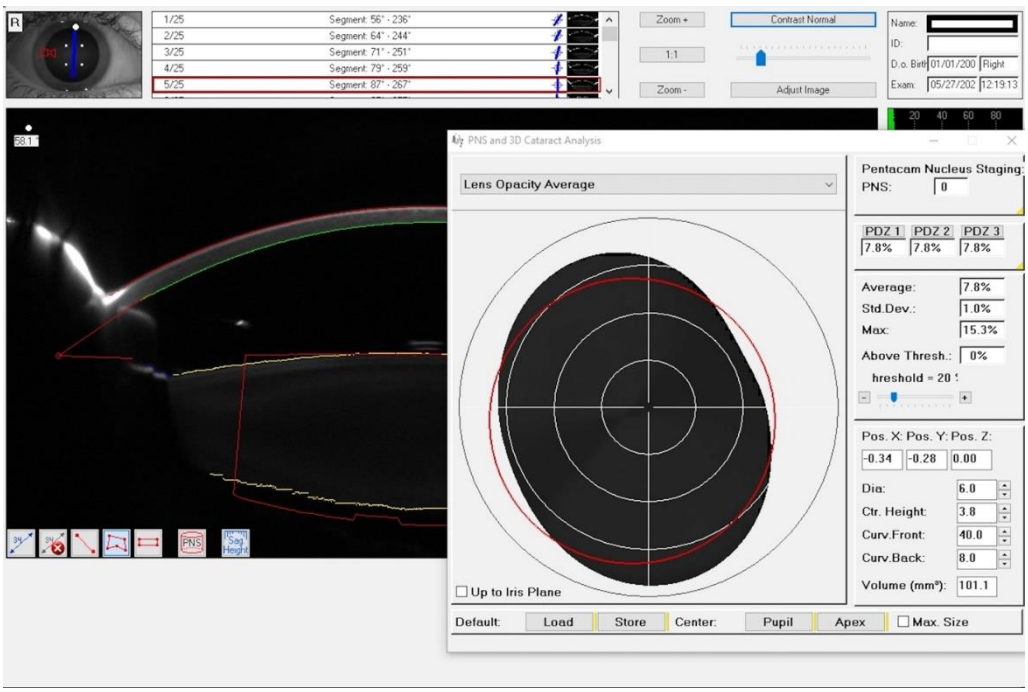

Figure 2. The crystalline lens densitometry measurements of patients.

Pentacam nucleus (PNS) staging (0–5), average lens density (ALD), maximum (Max) and lens thickness (LT) values were automatically determined in the device software (Figure 2). The following data have been analyzed from the acquisition prior to pupillary dilation. 1) Flat keratometry (K1) and steep keratometry (K2) for the central 3.0 mm of the cornea, maximum keratometry (Kmax), the central, apical, and thinnest corneal thickness (CCT, ACT, and TCT respectively) 2) Corneal volume (CV), chamber volume (ChV), anterior chamber depth (ACD), horizontal white to white (HWTW) and iridocorneal angle (ICA) 3) Corneal densitometry (CD) values were recorded separately in all zones in the anterior, center, and posterior layers. Crystalline lens density data obtained from measurements made after pupillary dilatation were recorded (PDZ1, PDZ2, PDZ3, PNS staging, ALD, Max, and LT).

2.2. Statistical Analysis

The data was examined by the Shapiro Wilk test whether or not it presents normal distribution. The results were presented as mean ± standard deviation or frequency and percentage. Normally distributed data were

compared with independent samples t-test. Categorical variables were compared using Pearson's Chi-square test between groups. Correlations between variables were tested using Pearson correlation coefficient. P< 0.05 was considered as significance levels. Statistical analyses were performed with IBM SPSS ver.23.0 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp).

3. Results

For the study, 34 beta thalassemia patients were examined. Two of the patients were excluded from the study due to lens opacity and corneal scarring. The study group consisted of 32 β-thalassemia major patients and the control group consisted of 31 healthy volunteers. Of the 32 patients in the study group, 15 were female and 17 were male. In the control group, 21 were female and 10 were male. The mean age of the study group was 12.12 ± 3.94 years (range: 5-19 years) and 10.90 ± 3.84 years (range: 5-19 years) in the control group. There was no statistically significant difference between age and gender in both groups (P>0.05). Demographic data of the study and control groups, mean age at diagnosis (months), duration of diagnosis (years), blood hemoglobin and ferritin levels of patients with β-thalassemia major are summarized in Table 1.

Among the corneal topographic parameters, CCT (544.25±30.45 vs. 562.23±30.95; P=0.025) and CV (59.97±3.26 vs. 62.60±3.54; P=0.004) were found to be significantly lower in the study group. All data are shown in Table 2.

Table 1. Demographic features

	Study Group (n=32)	Control Group (n=31)	P value
Age (years)	12.12 ± 3.94 (5 - 19)	10.9 ± 3.84 (5 - 19)	0.218*
Gender			0,094‡
Female	15 (46.9 %)	21 (67.7 %)	
Male	17 (53.1 %)	10 (32.3 %)	
Age at Diagnosis (months)	11.07 ± 5.76 (2 - 36)		
Duration of diagnosis (years)	11.10 ± 4.14 (4 - 19)		
Hemoglobin (g/dL)	8.98 ± 1.02 (6.1 - 10.8)	13.07 ± 0.58 (11.90 -14.1)	<0.0001*
Ferritin (nmol/L)	1692.59 ± 1199.7 (334 – 6092)	53.72 ± 23.09 (30-75)	<0.0001*

Descriptive statistics were given for continuous variables as mean ± standard deviation (SD) with minimum and maximum values and frequency and percentage for categorical variables. *= Independent samples t test, ‡= Chi-square test.

Table 2. Comparison of corneal topographic parameters data between study and control groups

	Study Group (n = 47)	Control Group (n = 47)	P value*
K1 (D)	42.86 ± 1.30 (39.2–46.80)	43.39 ± 1.36 (40.70–46.60)	0.123
K2 (D)	43.80 ± 1.54 (40.0–47.90)	44.29 ± 1.48 (42.00–48.40)	0.209
CCT (µm)	544.25 ± 30.45 (459–593)	562.23 ± 30.95 (499–617)	*0.025*
ACT (µm)	546.34 ± 30.76 (461–593)	563.13 ± 30.88 (498–618)	*0.036*
TCT (µm)	541.50 ± 30.66 (457–589)	559.27 ± 30.79 (497–615)	*0.026*
Kmax Front (D)	44.38 ± 1.61 (40.50–48.60)	44.74 ± 1.51 (42.30–48.80)	0.379
CV (mm^3)	59.97 ± 3.26 (51.10–64.30)	62.60 ± 3.54 (57.0–70.20)	*0.004*
ChV	178.41 ± 31.93 (128–251)	180.13 ± 23.81 (131–241)	0.809
ACD	3.08 ± 0.2 (2.14–3.70)	3.02 ± 0.3 (2.32–3.60)	0.362
HWTW	11.88 ± 0.41 (11.10–13.00)	11.68 ± 0.41 (10.70–12.40)	0.059
ICA (º)	36.90 ± 5.30 (27.60–45.20)	36.94 ± 4.55 (26.10–43.50)	0.975

Descriptive statistics were given for continuous variables as mean ± standard deviation (SD) with minimum and maximum values and frequency for categorical variables. K1= flat keratometry; K2= steep keratometry; D= diopter; CCT= central corneal thickness; ACT= apical corneal thickness; TCT= thinnest corneal thickness; Kmax= maximum keratometry; CV= corneal volume; ChV= chamber volume;

ACD= anterior chamber depth; HWTW= horizontal white to white; ICA= irido-corneal angle.

Only in the posterior layer corneal light backscattering was significantly lower in the patient group than in the normal group. There was no significant difference in corneal densitometry values in all other layers. All data are shown in Table 3.

Endothelial cell density counted by specular microscopy was determined as 3053.55±189.71 in the patient group and 3214±195.12 in the control group. The difference in ECD between the two groups was not statistically significant (P=0.094). The CoV and hex values were found to be similar in both groups.

The lens densitometry values did not differ between the two groups in all zones (P>0.05). All data are shown in Table 4.

Correlations between age, Hb, ferritin levels, disease duration, and ocular changes were evaluated. Only ferritin levels were found to be correlated with corneal densitometry. Corneal density of anterior layer (r=−0.453, P=0.014) and corneal density of central layer (r=−0.467, P=0.011) were negatively correlated with ferritin.

Table 3. Comparison of Corneal densitometry measurements

	Study Group (n = 32)	Control Group (n = 31)	P value*
Anterior Layer			
0-2 mm	25.03 ± 2.42	25.08 ± 1.17	0.921
2-6 mm	22.02 ± 2.23	22.36 ± 1.04	0.452
6-10 mm	19.24 ± 3.61	19.93 ± 2.75	0.405
10-12 mm	25.69 ± 6.14	27.94 ± 7.22	0.191
Total	22.23 ± 3.02	22.87 ± 2.02	0.335
Central Layer			
0-2 mm	15.25 ± 1.53	15.44 ± 0.86	0.546
2-6 mm	13.38 ± 1.31	13.67 ± 0.77	0.283
6-10 mm	11.93 ± 1.75	12.66 ± 1.43	0.079
10-12 mm	15.78 ± 3.31	15.25 ± 3.83	0.170
Total	13.58 ± 1.63	14.33 ± 1.17	0.043
Posterior Layer			
0-2 mm	12.51 ± 1.17	12.98 ± 0.98	0.094
2-6 mm	11.32 ± 1.01	11.85 ± 0.84	0.029
6-10 mm	10.92 ± 1.30	11.98 ± 1.31	0.002
10-12 mm	12.90 ± 2.41	15.25 ± 3.83	0.005
Total	11.64 ± 1.14	12.54 ± 1.05	0.002
Total Layer			
0-2 mm	17.43 ± 1.86	17.84 ± 0.81	0.268
2-6 mm	15.43 ± 1.60	15.95 ± 0.76	0.105
6-10 mm	13.97 ± 2.22	14.86 ± 1.78	0.088
10-12 mm	18.07 ± 3.80	20.40 ± 4.64	0.034
Total	15.71 ± 2.00	16.58 ± 1.33	0.051

Descriptive statistics were given for continuous variables as mean ± standard deviation (SD). *=Student's t-test were used.

Table 4. Comparison of lens densitometry measurements

	Study Group	Control Group	P value*
PDZ 1	7.95 ± 0.27	7.92 ± 0.20	0.556
PDZ 2	7.93 ± 0.25	7.95 ± 0.22	0.713
PDZ 3	7.97 ± 0.22	8.02 ± 0.27	0.399
ALD	7.96 ± 0.25	8.00 ± 0.22	0.446
SD	1.13 ± 0.46	1.27 ± 0.25	0.147
MAX	22.17 ± 10.11	19.08 ± 3.63	0.123
Lens thickness	3.63 ± 0.18	3.61 ± 0.21	0.773

Descriptive statistics were given for continuous variables as mean ± standard deviation. PDZ= pentacam densitometry of zone, ALD= average lens density, SD= standard deviation, Max= maximum, *=Student's t-test were used.

4. Discussion

In this study, non-invasive Pentacam imaging was performed to detect corneal, and lens changes early in β-thalassemia major patients without any ocular signs or symptoms. The cornea and lens density values of healthy children and patients with β-thalassemia major were compared in different layers and zones. We aimed to detect disease-related ocular complications early before

symptoms develop. Corneal densitometry is an indicator of corneal transparency. The cornea maintains its clarity through the regular lattice arrangement of collagen fibrils in the stroma. The main sources of light scattering are the corneal epithelium and corneal endothelial layer (Smith et al., 1990). Nerves and cell nuclei in the corneal tissue are the structures with the highest backscattering indices of light (Otri et al., 2012). In the current study, corneal densitometry values were found to be lower in the thalassemia group than in the control group only in the posterior 60-micron layer of the cornea. Although the endothelial cell density value was found to be higher in the healthy group (3214±195.129) than thalassemia group (3053.55±189.71) in specular microscopic evaluation, the difference was not statistically significant (P=0.094).

Patients with thalassemia are exposed to chronic hypoxia due to anemia. It is known that chronic hypoxia has negative effects on the corneal endothelium. In the study of Coskun et al. (2015) in patients with sickle cell anemia, it was shown that corneal endothelial cells and CCT decreased, and it was observed that chronic anemia and hypoxia caused morphological changes in the structure of the cornea. In our study, ECD was lower in the patient group, but we could not statistically prove corneal endothelial cell loss. We hypothesize that the decrease in densitometry detected in the posterior corneal layer is due to changes in the structural properties of the cornea endothelium. In a study conducted in high myopic eyes, the corneal posterior layer density was found to be lower than the control. It has been suggested that the density of endothelial cells, which are part of the luminescent corneal tissue, is reduced in high myopic eyes (Dong et al., 2018).

Previous studies on biometric parameters and refractive errors in thalassemia patients found a shorter axial length and ACD, a steeper cornea, and a thicker lens compared to normal subjects. It has been suggested that this is to compensate for growth retardation due to growth hormone deficiency and orbital bone changes (Nowroozzadeh et al., 2011; Elkitkat et al., 2018). In this study, no difference was found between the patient and control groups in terms of corneal curvature, ACD, and lens thickness. Corneal thickness measurements and corneal volume were statistically significant lower in the thalassemia group. There are many factors that can cause ocular disorders due to thalassemia, such as chronic anemia, iron overload, chelation drugs used and growth and development retardation. However, we suggest that the reason for the lower corneal thickness measurement and volume is due to growth retardation. In animal studies, it has been shown that growth hormone, Insulin like growth factor 1 (IGF-1) and recombinant growth factor therapy cause extracellular matrix synthesis and stimulate the development of ocular tissues (Burren et al., 1996). In addition, Dereli and Kara (2019) observed a mild to moderate positive correlation between IGF-1 values and ACT and CV values.

The biometric and refractive characteristics of the thalassemia major patients have previously been investigated (Heydarian et al., 2016; Elkitkat et al., 2018). Patients with thalassemia major have been shown to have a lower axial length compared to controls. It is due to the bone structure of the orbit, which is due to skeletal disorders as a result of bone marrow enlargement. In the study of Heydarian et al. (2016) in adult thalassemia patients, the mean axial length was significantly lower in thalassemia patients than in the normal group, and the flattest meridian of the cornea was significantly steeper in thalassemia patients. They argue that this is because there may be steeper corneal curvatures that overcome the refractive disadvantage of shorter axis lengths. In our study, we did not evaluate the axial length of the patients. Unlike the other study, we did not detect a significant difference in the radius of corneal curvature, since pediatric patients who did not complete the emmetropization process were included in the study and the compensation mechanisms that would develop in the cornea and lens would not have been completed yet.

Previous studies have shown an increase in LT in thalassemia patients (Nowroozzadeh et al., 2011; Elkitkat et al., 2018; El-Haddad, 2020). The reason for this has not been fully explained. It has been discussed that the precipitation of iron in the lens material may be due to the chelating agents used. One of the mechanisms proposed is that the cornea becomes steeper, and the lens becomes thicker to compensate for the shorter axial length in thalassemia patients (Heydarian et al., 2016). In the current study, we did not detect a significant difference between the control group and thalassemia patients in terms of lens thickness. Unlike other studies, lens thickness measurement was evaluated with Pentacam for the first time, not ultrasonic method. Other differences are that the mean age of the patients included in the study was lower than in other studies, and patients with cataract were excluded from the study. In different studies, the prevalence of cataracts in patients with b-thalassemia ranged from 6.3% to 45.7% (Heydarian et al., 2020). It is argued that the factor contributing to the development of cataract in patients with β-thalassemia may be due to free radical damage due to iron overload, chelating agents used, and nutritional deficiencies (Popescu et al., 1998; Athanasiadis et al., 2007; Taneja et al., 2010). Jafari et al. (2015) detected cataracts in 10.2% of thalassemia patients aged 14-42 years. They reported that the prevalence of cataract was higher in patients using deferiprone. Taneja et al. (2010) found lens opacity in 40% of thalassemia patients aged 6 months to 21 years. They found that the prevalence of cataracts was higher in patients receiving desferrioxamine treatment than in patients receiving deferiprone.

Although the cause of cataract in thalassemia patients is not clear, it has been proven in many studies that its prevalence increases. Based on the literature, we aimed to evaluate the lens densitometry with a Pentacam device and to follow up the patients with high lens densitometry

values to detect the signs of cataract before it develops clinically in thalassemia patients. In this study, lens densitometry in all zones showed similar results in thalassemia and control groups. Although only the maximum lens density was found to be high in the thalassemia group, no statistically significant difference was observed.

5. Conclusion

In conclusion, we found a change in corneal densitometry without any clinical findings in patients with β-thalassemia major. Although no significant difference was detected in the lens density of our patients, changes in the Max value may be a new hope for Pentacam, which is a non-invasive and fast method, especially in early indication of lens opacities. This finding should be supported by prospective studies with a large number of cases.

To our knowledge, this study is the first to evaluate anterior segment structures in children with β-thalassemia using Pentacam. Another strength of the study is the prospective patient recruitment and the inclusion of patients with no ocular pathology in the eye examination. However, the small sample size is an important limitation due to the poor cooperation of younger age groups with the device during examination in the pediatric group. Since there is no study with Pentacam in the literature, it was not possible to compare the data. Prospective evaluation with larger numbers of patients is needed to determine whether Pentacam will be an appropriate screening technique for early detection of β-thalassemia ocular findings in children.

Author Contributions

Concept: H.G.U. (%50) and E.G.K. (50%), Design: H.G.U. (%50) and E.G.K. (50%), Supervision: H.G.U. (%50) and E.G.K. (50%), Data collection and/or processing: H.G.U. (%50) and E.G.K. (50%), Data analysis and/or interpretation: H.G.U. (%50) and E.G.K. (50%), Literature search: H.G.U. (%50) and E.G.K. (50%), Writing: H.G.U. (%50) and E.G.K. (50%), Critical review: H.G.U. (%50) and E.G.K. (50%), Submission and revision H.G.U. (%50) and E.G.K. (50%). All authors reviewed and approved final version of the manuscript.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Approval/Informed Consent

The study protocol was approved by the Bursa University of Health Sciences local ethics committee (2011- KAEK-25 2021/04-30) in accordance with the principles of the Helsinki declaration. Written informed consent was obtained from the children and their parents before participating in the study.

Acknowledgements

The authors thank to Doç. Dr. Güven Özkaya for statistical analysis of the article and thank to Özgü Aybayar and Osman Avcı for the technical support of the device.

References

Athanasiadis I, Konstantinidis A, Kyprianou I, Robinson R, Moschou V, Kouzi-Koliakos K. 2007. Rapidly progressing bilateral cataracts in a patient with beta thalassemia and pellagra. J Cataract Refract Surg, 33(9): 1659-1661. DOI: 10.1016/j.jcrs.2007.05.011.

Burren CP, Berka JL, Edmondson SR, Werther GA, Batch JA. 1996. Localization of mRNAs for insulin-like growth factor-I (IGF-I), IGF-I receptor, and IGF binding proteins in rat eye. Invest Ophthalmol Vis Sci, 37(7): 1459-1468.

Consejo A, Alonso-Caneiro D, Wojtkowski M, Vincent SJ. 2020. Corneal tissue properties following scleral lens wear using Scheimpflug imaging. Ophthalmic Physiol Opt, 40(5): 595-606. DOI: 10.1111/opo.12710.

Coşkun M, İlhan Ö, İlhan N, Tuzcu EA, Daglioğlu MC, Kahraman H, Helvaci MR. 2015. Changes in the cornea related to sickle cell disease: a pilot investigation. Eur J Ophthalmol, 25(6): 463-467. DOI: 10.5301/ejo.5000598.

Demosthenous C, Vlachaki E, Apostolou C, Eleftheriou P, Kotsiafti A, Vetsiou E, Sarafidis P. 2019. Beta-thalassemia: renal complications and mechanisms: a narrative review. Hematology, 24(1): 426-438.

Dereli Can G, Kara Ö. 2019. Noninvasive evaluation of anterior segment and tear film parameters and morphology of meibomian glands in a pediatric population with hypogonadism. Ocul Surf, 17(4): 675-682. DOI: 10.1016/j.jtos.2019.09.001.

Dong J, Zhang Y, Zhang H, Jia Z, Zhang S, Sun B, Wang X. 2018. Corneal densitometry in high myopia. BMC Ophthalmol, 18(1): 182. DOI: 10.1186/s12886-018-0851-x.

El-Haddad NS. 2020. Anterior chamber angle, intraocular pressure, and globe biometric parameters in the children with β-thalassemia major. J Curr Glaucoma Pract, 14(1): 30-36. DOI: 10.5005/jp-journals-10078-1274.

Elkitkat RS, El-Shazly AA, Ebeid WM, Deghedy MR. 2018. Relation of anthropometric measurements to ocular biometric changes and refractive error in children with thalassemia. Eur J Ophthalmol, 28(2): 139-143. DOI: 10.5301/ejo.5000903.

Heydarian S, Jafari R, Dailami KN, Hashemi H, Jafarzadehpour E, Heirani M, Khabazkhoob M. 2020. Ocular abnormalities in beta thalassemia patients: prevalence, impact, and management strategies. Int Ophthalmol, 40(2): 511-527. DOI: 10.1007/s10792-019-01189-3.

Heydarian S, Jafari R, Karami H. 2016. Refractive errors and ocular biometry components in thalassemia major patients. Int Ophthalmol, 36(2): 267-271. DOI: 10.1007/s10792-015-0161-8.

Jafari R, Heydarian S, Karami H, Shektaei MM, Dailami KN, Amiri AA, Far AA. 2015. Ocular abnormalities in multi-transfused beta-thalassemia patients. Indian J Ophthalmol, 63(9): 710-715. DOI: 10.4103/0301-4738.170986.

Kadhim KA, Baldawi KH, Lami FH. 2017. Prevalence, Incidence, Trend, and Complications of Thalassemia in Iraq. Hemoglobin, 41(3): 164-168.

Nowroozzadeh MH, Kalantari Z, Namvar K, Meshkibaf MH. 2011. Ocular refractive and biometric characteristics in patients with thalassaemia major. Clin Exp Optom, 94(4): 361-366. DOI: 10.1111/j.1444-0938.2010.00579.x.

Origa R. 1993. Beta-Thalassemia. In M. P. Adam, H. H. Ardinger, R. A. Pagon, S. E. Wallace, L. J. H. Bean, G. Mirzaa, & A.

Amemiya (Eds.), GeneReviews(®).University of Washington, Seattle, Seattle, WA, US.

Otri AM, Fares U, Al-Aqaba MA, Dua HS. 2012. Corneal densitometry as an indicator of corneal health. Ophthalmology, 119(3): 501-508.

Popescu C, Siganos D, Zanakis E, Padakis A. 1998. The mechanism of cataract formation in persons with beta-thalassemia. Oftalmologia, 45(4): 10-13.

Repanti M, Gartaganis SP, Nikolakopoulou NM, Ellina A, Papanastasiou DA. 2008. Study of the eye and lacrimal glands in experimental iron overload in rats in vivo. Anat Sci Int, 83(1): 11-16. DOI: 10.1111/j.1447-073X.2007.00195.x.

Shah R, Amador C, Tormanen K, Ghiam S, Saghizadeh M, Arumugaswami V, Ljubimov AV. 2021. Systemic diseases and the cornea. Exp Eye Res, 204: 108455.

Smith GT, Brown NA, Shun-Shin GA. 1990. Light scatter from the central human cornea. Eye, 4(4): 584-588. DOI: 10.1038/eye.1990.81.

Taneja R, Malik P, Sharma M, Agarwal MC. 2010. Multiple transfused thalassemia major: ocular manifestations in a hospital-based population. Indian J Ophthalmol, 58(2): 125-130. DOI: 10.4103/0301-4738.60083.