Anterior Chamber Angle, Intraocular Pressure, and Globe Biometric Parameters in the Children with β-Thalassemia Major

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ABSTRACT

Background: To evaluate the intraocular pressure (IOP), anterior chamber angle (ACA), and globe biometric parameters in β-thalassemia major children and the correlations of these changes.

Materials and methods: Eighty-four eyes were included (42 eyes of thalassemia patients and 42 eyes of control). All participates underwent head circumference and height measurements, full ophthalmic examination, anterior segment optical coherence tomography (AS-OCT), and A-scan biometry.

Results: The temporal angle of anterior chamber (T-ACA) was significantly narrower in thalassemia patients with p value = 0.008. While the nasal angle showed a nonsignificant narrowing with p value = 0.153. This narrowing was positively correlated with the height, and negatively correlated with the head circumference. Intraocular pressure was statistically higher in thalassemia patients with p value = 0.000. The increased IOP was positively correlated with the head circumference and the lens thickness (LT) and negatively correlated with T-ACA, axial length (AL), vitreous chamber depth (VCD), and anterior chamber depth (ACD). Axial length, ACD, and VCD significantly decreased with p value = 0.000 for all with a positive correlation with the height and a negative correlation with the head circumference. The LT increased in thalassemia group with p value = 0.000. This increase was positively correlated with the head circumference and negatively with the height. Also, there was steeper corneal curvature in thalassemia group with p value = 0.023 and 0.015 (for K_1 and K_2, respectively). No significant change was observed in corneal thickness in both groups with p value = 0.810.

Conclusion: Narrower T-ACA, increased IOP, shorter (AL, VCD, and ACD), steeper corneal curvature, and thicker lens were found in thalassemia patients.

Keywords: Anterior chamber angle, Corneal curvature, Effective lens position, Globe biometric parameters and intraocular pressure, β-Thalassemia.

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INTRODUCTION

One of the most common inherited blood disorders is thalassemia major. It is caused by mutation in the gene responsible for the synthesis of the beta chain of adult hemoglobin. Red blood cell maturation leads to ineffective erythropoiesis.[1] Chronic anemia, iron accumulation in the tissues resulting from the red blood cell destruction, repeated blood transfusion, and the use of iron chelators (all these factors) affect organs negatively.[2]

β-Thalassemia affects more than 42,000 newborns every year all over the world. Populations with the highest prevalence are the Mediterranean, Central Asia, Middle East, India, and the Far East.[3]

β-Thalassemia major has both systemic and ocular affections. β-Thalassemia affects both anterior and posterior segments of the eye. Ocular surface disorder with goblet cell loss and squamous metaplasia of the conjunctiva,[4] abnormal conjunctival vessels, against-the-rule pattern astigmatism, steeper corneal curvature, cataract, and thicker lens are some of the anterior segment manifestations of β-thalassemia major. However, retinal pigment epithelium (RPE) degeneration, RPE hypertrophy, angioid streaks, venous tortuosity, and optic nerve head drusen are some posterior segment manifestations. Other manifestations include shorter axial length (AL),[2] color blindness, and decrease in the visual acuity.

The aim of this study was to find the effect of β-thalassemia on the angle of anterior chamber (ACA), intraocular pressure (IOP), and the other globe parameters.

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MATERIALS AND METHODS

The study included 84 eyes. Forty-two eyes of children with thalassemia major (18 male and 24 female) and 42 eyes of control healthy children of the same age-group (12 male and 30 female). The thalassemia major children are on blood transfusion iron-chelating agents. Informed consent was obtained from the parents after detailed information was given. The study protocol was approved by the declaration of Helsinki protocol.

Exclusion criteria included amblyopia, aphakia, strabismus, cataract surgery, history of corneal disease, and systemic disease effect on refractive errors.

Head circumference, height, and weight were recorded for all patients. Complete ophthalmologic examinations were performed

for all participants, including the best corrected visual acuity (BCVA), slit lamp biomicroscopic examination, external eye examination, IOP by Goldmann applanation tonometery and fundoscopy.

Refraction

Cycloplegic refraction (using 0.5% cyclopentolate hydrochloride) and the corneal astigmatism were determined using an auto kerato-refractometer. The final result was taken as the average of three consecutive readings.

Anterior Segment Optical Coherence Topography

NIDEK RS-3000 retinal scan with anterior segment module was used for anterior segment optical coherence topography (AS-OCT) measurements. Patients, with undilated pupils, fixated to AS-OCT. The ACA line was used to image the nasal and temporal angle quadrants (180° and 0° meridians). Both the quality and centration of image should be sufficient for analysis. The central corneal thickness (CCT) was measured using the cornea radial scan pattern. The best images were selected for being analyzed to measure the CCT and ACA.

The ACA width was calculated by measuring the angle between the iris tangential line and the posterior corneal surface with its apex in the angle recess.

A-scan Ultrasonography

A-scan ultrasonography was used for measurement of ocular components anterior chamber depth (ACD), lens thickness (LT), AL, and vitreous chamber depth (VCD). The monitor A&B scan biometer was used following corneal anesthesia with tetracaine HCL. The patients were requested to lay in a supine position and look at a far object to neutralize the accommodation effect on the measured LT. The fingers were used to hold the lids apart. Excessive pressure on the globe should be avoided. The measures were obtained by applying the probe tip to touch the cornea. Five measurements per eye were taken. Relative lens position is the relative position of the center of the lens which is calculated by adding half the LT to the ACD and then dividing the sum by the AL multiplied by 10 [ACD + 0.5 × LT/AL × 10].

The data were collected and then statistically analyzed by using Mann–Whitney test, independent *t* test, Chi-square test, and Spearman test.

RESULTS

In this study, the mean age of thalassemia patients was 16.43 ± 3.99, and for the control group was16.29 ± 3.83. The height of thalassemia patients was significantly shorter than the control group with *p* value of 0.000. However, the head circumference in thalassemia group was more than the control group with *p* value of 0.000 (Table 1). An insignificant change was observed in best corrected visual acuity (BCVA) with *p* value of 0.306 (Table 2).

As regards the ACA, the temporal angle (T-ACA) in thalassemia patients was significantly narrower than the control group with

Table 1: Demographic and general characteristics of participants

		Control group	Patient group			
		No. = 42	No. = 42	Test value	p value	Sig.
Sex	Male	12 (71.4%)	18 (57.1%)	0.622	0.430	NS
	Female	30 (28.6%)	24 (42.9%)			
Age	Mean ± SD	16.29 ± 3.83	16.43 ± 3.99	−0.097	0.924	NS
	Range	10–21	9–21			
Height	Mean ± SD	153.71 ± 3.67	148.57 ± 2.65	4.252	0.000	HS
	Range	149–159	143–151			
Head circumference	Mean ± SD	53.93 ± 0.76	55.67 ± 0.77	−6.051	0.000	HS
	Range	53–55	54.5–57			

Table 2: Anterior chamber angles, corneal astigmatism, corneal thickness, intraocular pressure, and visual acuity in thalassemia patients and control group

		Control group	Patient group			
		No. = 42	No. = 42	Test value	p value	Sig.
T-ACA	Mean ± SD	35.64 ± 2.30	33.23 ± 2.09	2.896	0.008	HS
	Range	29.9–38.2	29.5–35.9			
N-ACA	Mean ± SD	33.28 ± 3.47	31.64 ± 2.29	1.473	0.153	NS
	Range	23.9–36.7	26.8–35.6			
C.astig	Median (IQR)	−0.75 (−1 to −0.5)	−0.75 (−1.25 to −0.75)	0.601	0.635	NS
	Range	−2.25 to −0.25	−1.75 to −0.25			
Axis	Median (IQR)	34.00 (13–113)	91.00 (76–100)	0.148	0.150	NS
	Range	4–182	47–176			
IOP	Mean ± SD	12.07 ± 1.33	15.21 ± 1.12	−6.765	0.000	HS
	Range	10–14	13–17			
Corneal thickness	Mean ± SD	511.86 ± 8.75	510.64 ± 16.57	0.242	0.810	NS
	Range	495–525	487–545			
BCVA	Median (IQR)	0.00 (0–0)	0.00 (0–0.2)	0.205	0.306	NS
	Range	0–0.2	0–0.3			

T-ACA, temporal anterior chamber angle; N-ACA, nasal anterior chamber angle; C.astig, corneal astigmatism; IOP, intraocular pressure; BC VA, best corrected visual acuity

p value of 0.008. While the nasal angle showed a nonsignificant narrowing with *p* value of 0.153 (Table 2), the angle of anterior chamber was positively correlated with height and negatively correlated with the head circumference and IOP. The IOP was statistically higher in thalassemia patients with *p* value of 0.000 (Table 2). The increased IOP was positively correlated with the head circumference and the LT. However, it was negatively correlated with T-ACA, AL, VCD, and ACD (Figs 1 to 5).

AL, ACD and VCD were significantly shorter in in thalassemia group than the control group with *p* value = 0.000 for all (Table 3); AL, ACD, and VCD were positively correlated with the height and negatively correlated with the head circumference and IOP (Figs 6 to 17).

The lens was thicker in the thalassemia group than the control group with *p* value of 0.000 (Table 3). This increase in LT was positively correlated with the head circumference and IOP but negatively correlated with the height (Table 4). As regards relative lens position, no difference was found between both groups with *p* value of 0.090 (Table 3).
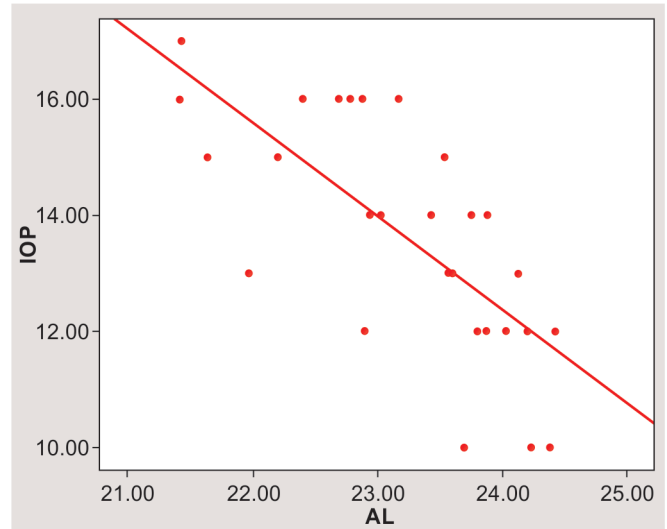
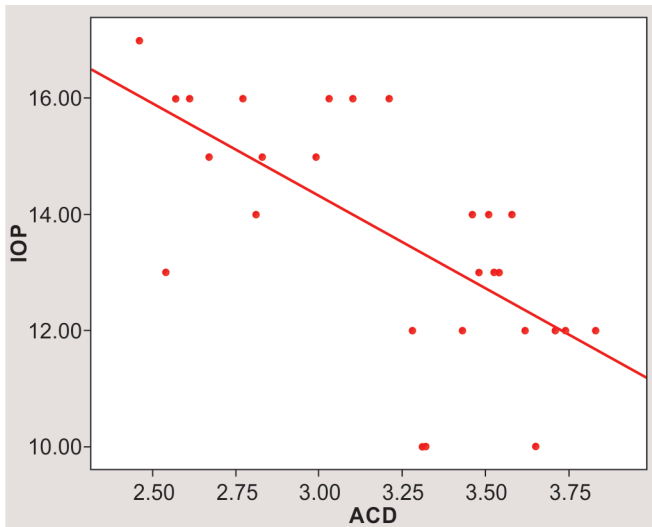**Fig. 1:** A negative correlation between intraocular pressure and axial length

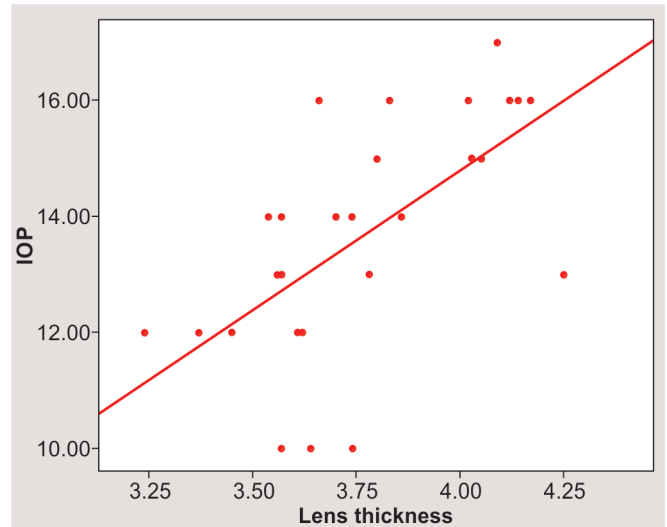**Fig. 2:** A negative correlation between intraocular pressure and anterior chamber depth

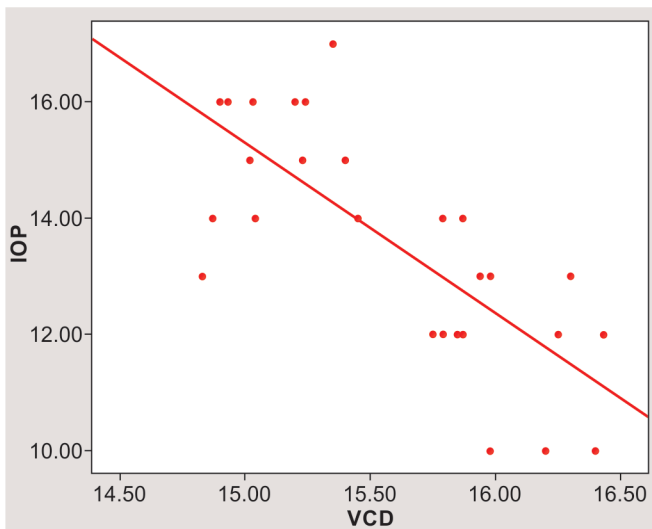**Fig. 3:** A positive correlation between intraocular pressure and lens thickness

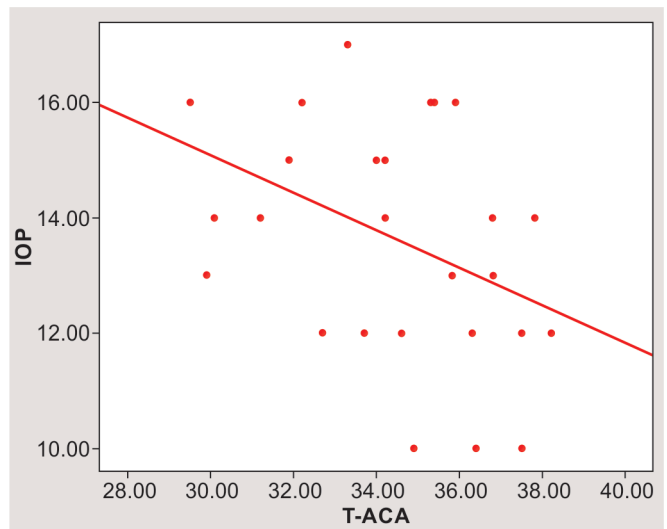**Fig. 4:** A negative correlation between intraocular pressure and vitreous chamber depth

Fig. 5: A negative correlation between intraocular pressure and temporal anterior chamber angle

Table 3: Biometric parameters for the control and thalassemia groups

		Control group	Patient group			
		No. = 42	No. = 42	Test value	p value	Sig.
AL	Mean ± SD	23.87 ± 0.41	22.56 ± 0.74	5.742	0.000	HS
	Range	22.9–24.42	21.42–23.75			
ACD	Mean ± SD	3.54 ± 0.17	2.89 ± 0.33	6.579	0.000	HS
	Range	3.28–3.83	2.46–3.46			
Lens thickness	Mean ± SD	3.56 ± 0.14	3.96 ± 0.19	−6.310	0.000	HS
	Range	3.24–3.78	3.66–4.25			
Vitreous chamber depth	Mean ± SD	16.03 ± 0.24	15.10 ± 0.21	10.960	0.000	HS
	Range	15.75–16.43	14.83–15.45			
Relative lens position	Mean ± SD	2.22 ± 0.08	2.16 ± 0.10	1.763	0.090	NS
	Range	2.05–2.34	2.01–2.32			
K1	Mean ± SD	41.59 ± 1.52	42.88 ± 1.28	−2.419	0.023	S
	Range	37.5–43	41.75–45.5			
K2	Mean ± SD	42.44 ± 1.37	43.86 ± 1.50	−2.608	0.015	S
	Range	39.65–44	42.25–47			

AL, axial length; ACD, anterior chamber depth; K1, the flatter corneal curvature; K2, the steeper corneal curvature
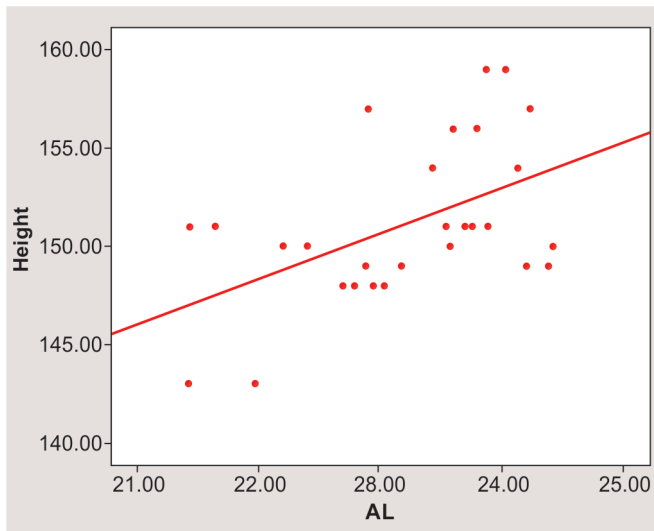

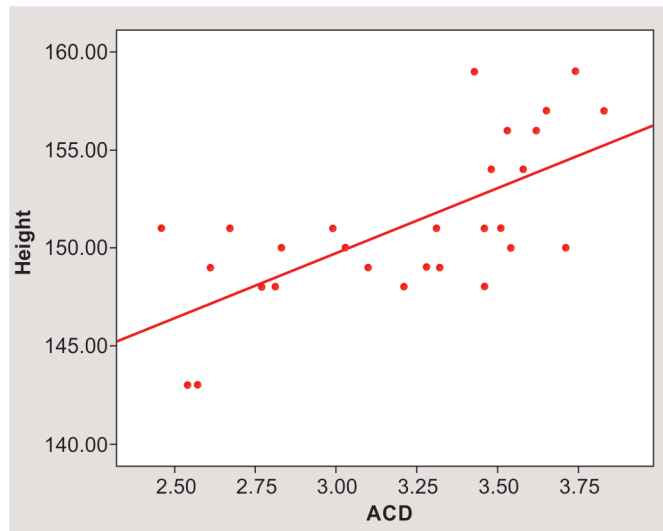**Fig. 6:** A positive correlation between height and axial length

Fig. 7: A positive correlation between height and anterior chamber depth
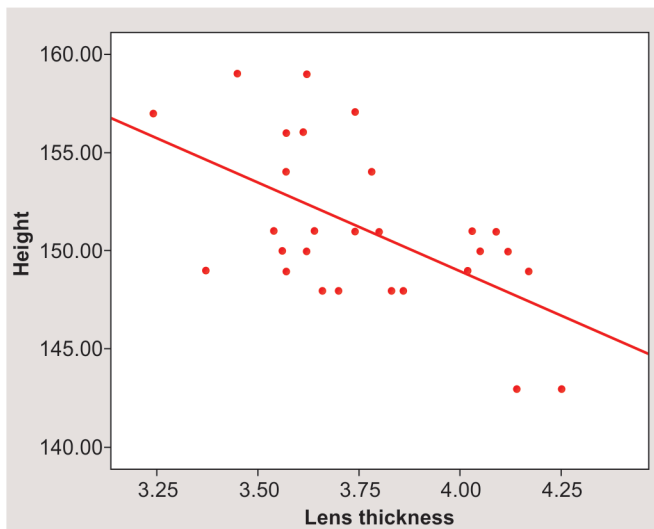

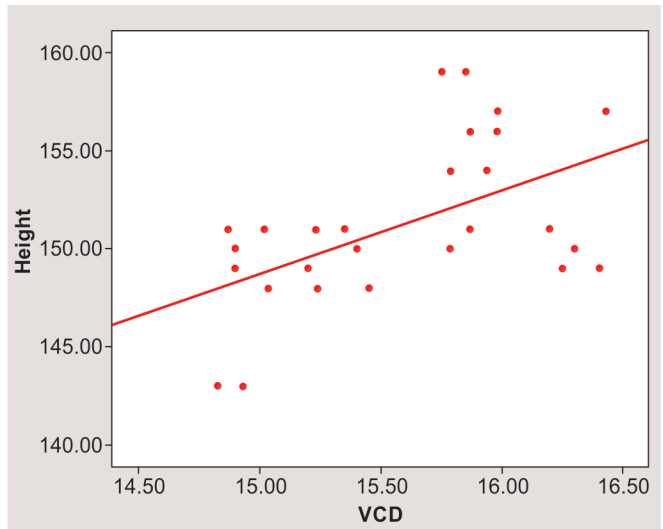**Fig. 8:** A negative correlation between height and lens thickness

Fig. 9: A positive correlation between height and vitreous chamber depth
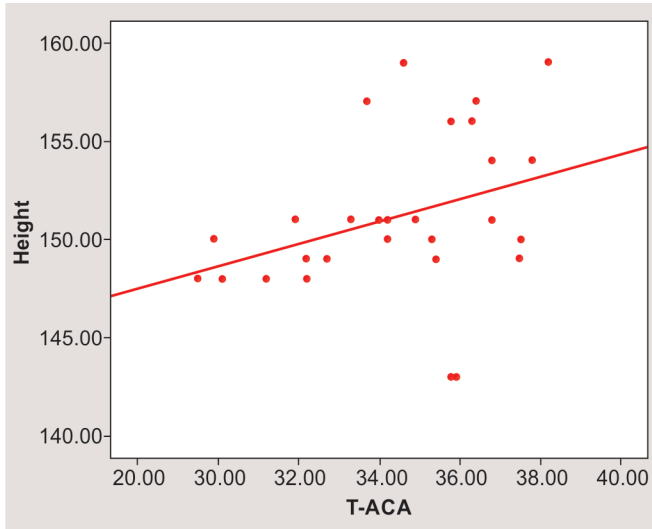
Fig. 10: A positive correlation between height and temporal anterior chamber angle
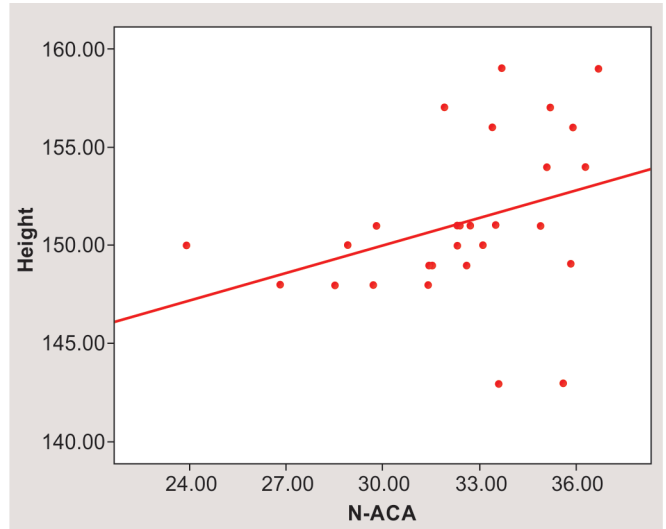

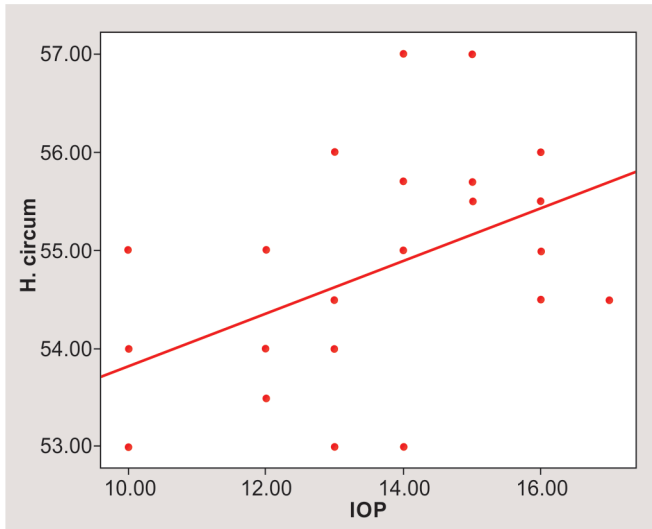**Fig. 11:** A positive correlation between height and nasal anterior chamber angle

Fig. 12: A positive correlation between the head circumference and intraocular pressure
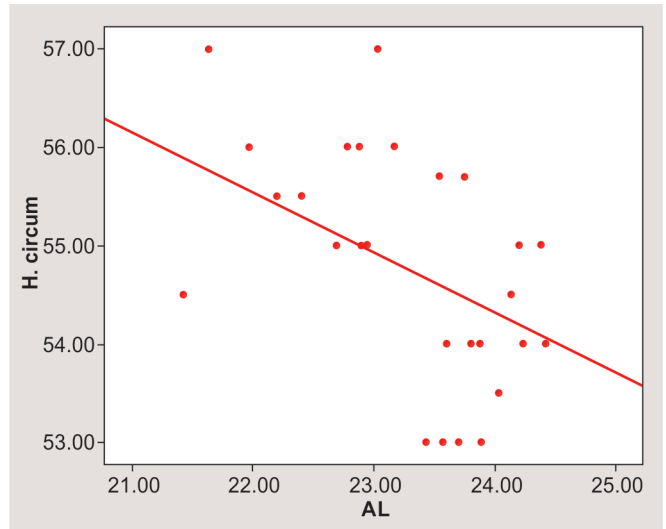

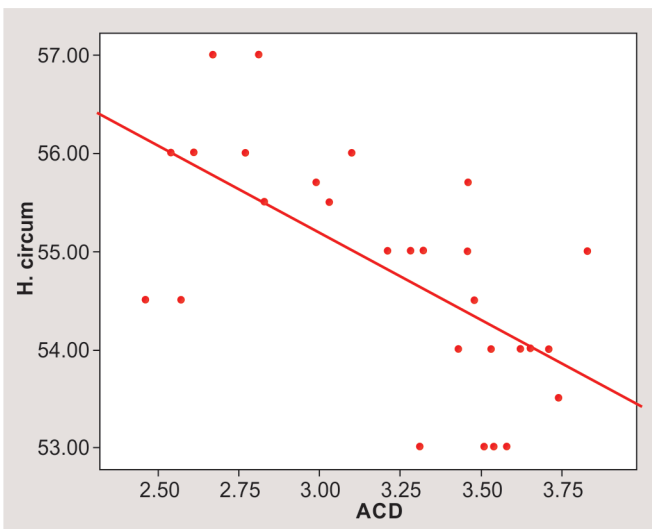**Fig. 13:** A negative correlation between the head circumference and axial length

Fig. 14: A negative correlation between the head circumference and anterior chamber depth
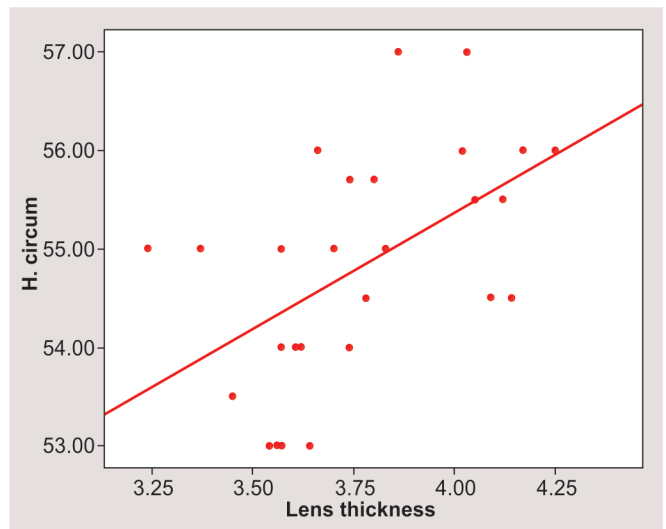

Fig. 15: A positive correlation between the head circumference and lens thickness
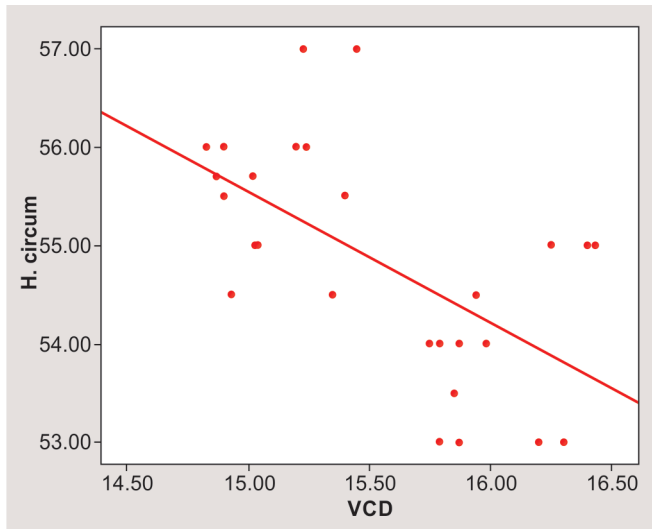
Fig. 16: A negative correlation between the head circumference and vitreous chamber depth
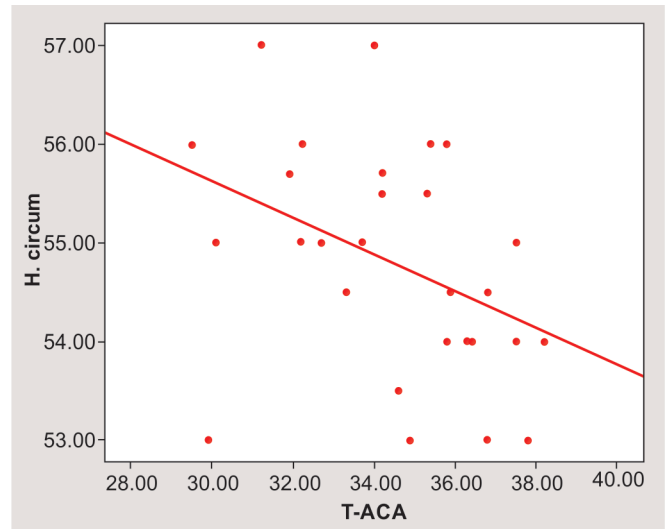

Fig. 17: A negative correlation between the head circumference and temporal anterior chamber angle

Table 4: Correlation of the parameters with height, head circumference, and intraocular pressure (IOP)

	Height		H. Circum		IOP	
	r	p value	r	p value	r	p value
Height	–	–	−0.535	0.003	−0.463	0.013
Head circumference	−0.535	0.003	–	–	−0.535	0.003
IOP	−0.463	0.013	0.501	0.007	–	–
AL	0.445	0.018	−0.501	0.007	−0.765	0.000
ACD	0.641	0.000	−0.663	0.000	−0.676	0.000
Lens thickness	−0.484	0.009	0.609	0.001	0.657	0.000
Vitreous chamber depth	0.477	0.010	−0.599	0.001	−0.725	0.000
T-ACA	0.407	0.032	−0.471	0.011	−0.427	0.024
N-ACA	0.464	0.013	−0.349	0.069	−0.338	0.078

AL, axial length; ACD, anterior chamber depth; IOP, intraocular pressure; T-ACA, temporal anterior chamber angle; N-ACA, nasal anterior chamber angle

Also, there was steeper corneal curvature in thalassemia group with p value of 0.023 and 0.015 (for K_1 and K_2, respectively). No significant change was observed in corneal thickness in both groups with p value of 0.810 (Table 3).

DISCUSSION

Thalassemia major is a hereditary disease that affects those living in the Mediterranean area, including Egypt, especially with a high incidence of the consanguineous marriages. The disease needs long-lasting follow-up and treatment. It creates an economic and social problem. Many factors affect the life span and the systemic symptoms such as the patient's socioeconomic and environmental situation. The progression of the disease in patients with thalassemia major, frequent blood transfusions, and the usage of chelating agents could affect the systemic symptoms.[5] So, it is important to study the effect of thalassemia in different countries.

In this study, ACA was reported to be narrower in thalassemia patients, T-ACA was statistically significant, but N-ACA was statistically nonsignificant. There were no references to other studies to compare these results with others. This narrowing in

T-ACA may be due to the increased length thickness that bush iris anteriorly, leading to T-ACA narrowing in the same mechanism of narrowing the angle with age. The affection of temporal angle with sparing of nasal angle is not well understood. But this finding has been found by Chen et al.[6] who reported that the temporal angle is the angle that narrows with age.

The corneal thickness in both groups was not statistically different. So the increased IOP in thalassemia patients reported in this study and in other studies was not due to the difference in pachymetery. But it may be due to steeper corneal curvature as explained by Nowroozzadeh et al.[7] However, the increased IOP in thalassemia patients may be due to the short AL, ACD, and VCD and due to the thick lens as supported by the negative correlation between the IOP and AL, ACD, and VCD found in this study (Figs 1 and 2). Also, the positive correlation between the LT and IOP reinforces this hypothesis. The narrower T-ACA may play a role in the increased IOP because a negative correlation between IOP and T-ACA was found in this study (Fig. 5).

Thalassemia major affects the biometric parameters of the globe. In this study, the AL, ACD, and VCD decreased in thalassemia patients. This matches with Khalaj et al.,[8] Nowroozzadeh et al.,[7]

Heydarian et al.,[9] and Elkitkat et al.[10] All reported shorter AL and ACD of thalassemia patients. This can be due to the skeletal abnormality affecting the bony orbit as a result of the bone marrow expansion. Pereira and Allemann[11] found a correlation between AL, ACD, VCD and the height in normal population. As thalassemia patients have shorter height, they have shorter AL, ACD, and VCD as a part of generalized growth retardation. This hypothesis was supported by the positive correlation between the AL, ACD, VCD, and the height found in my study (Figs 6 to 9).

This study demonstrated an increase in LT in thalassemia patients as reported in some studies.[7–10] The cause of this is not well understood. It might be due to precipitation of iron in lens matter. Despite the lens was thicker in thalassemia patients compared to the control, the relative lens position did not show statistical difference in both groups. This is because the increased LT is compensated by the short AL and ACD.

The thalassemia patients had steeper corneal curvature than the control group, which has been reported by Nowroozzadeh et al.,[7] Heydarian et al.,[9] and Elkitkat et al.[10] The cause of this steep cornea has not been understood yet, but the change in a bony orbit may be the cause or it may be a compensatory mechanism for short AL.

The steeper corneal curvature and the increased LT compensate shorter AL. So no statistical difference in BCVA.

CONCLUSION

Thalassemia affects ACA, IOP, and the biometric globe parameters. Narrower T-ACA and increased IOP were found in thalassemia patients. Shorter AL, VCD, and ACD were reported. Also, steeper corneal curvature and thicker lens were found. The CCT and the relative lens position were the same in both thalassemia patients and control groups.

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