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ORIGINAL PAPER

# Changes in choroidal tissue post-supplementation with vitamin D in pediatric patients who are deficient in vitamin D

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**Abstract**

*Purpose* To quantitatively assess the choroidal structural parameters of patients in the pediatric age group who were deficient in vitamin D [Vit-D] pre- and post-treatment.

*Design* Prospective, case–control study.

*Methods* Choroidal structural parameters, including the choroidal thickness (CT) at five points, total choroidal area (TA), luminal choroidal area (LA), stromal choroidal area (SA), and choroidal vascular index (CVI), in patients in the pediatric age group who were deficient in Vit-D, in Group 1, and those who were not, in Group 2, were compared. The patients were divided into 3 different groups according to how deficient in Vit-D they were. This was re-evaluated after treatment.

*Results* Group 1 consisted of 83 patients and group 2 consisted of 85 patients. CT at all five points, and the TA, SA, LA, and CVI, were lower in Group 1. And for all of these, a significant increase was seen post-treatment. While a significant increase was observed in all of the values in the group with the most severe deficiency in Vit-D, significant changes were observed in the TA, LA, SA, and CVI values in the group that was mildly deficient in Vit-D. There was no significant post-treatment value in the CT values (except for the Temporal 1500 CT [$P = 0.012$]).

*Conclusion* Decreases in the CT, TA, LA, SA, and CVI were among the structural changes that were seen to occur in the pediatric patient group that was deficient in Vit-D. Moreover, thinning of the choroid and a decrease in the CVI were the most significant in the group with the greatest Vit-D deficiency.

**Keywords** Choroidal thickness · Choroidal vascular index · Optical coherence tomography · Vitamin D deficiency

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## Introduction

Although vitamin D [Vit-D] is similar to standard steroid hormones in terms of molecular structure and function, it is a fat-soluble secosteroid [1].

Calcidiol, which is the inactive form of Vit-D (25[OH] D), is accepted as the most reliable biomarker in determining the Vit-D level of individuals [2]. Vit-D, when in its active form, (1, 25[OH] 2D3) [cholecalciferol], arranges the gene phrase in targeted cells and tissues via both genomic and non-genomic mechanisms and it also plays a role in modulating inflammation, oxidative stress, fibrosis, and angiogenesis [3–5]. In 2003, the American Academy of Pediatrics recommended supplementation with Vit-D for infants in their first two months of life [1]. Although genetic, dietary, and geographical factors are effective in the pediatric patient group that is deficient in Vit-D, it is seen more commonly in developing countries [1].

In the literature, it was reported that a deficiency in Vit-D is associated with many eye diseases, for example, glaucoma, dry eye, age-related macular degeneration, diabetic retinopathy, and uveitis [5]. Studies have shown that Vit-D as well as its metabolites are found in both aqueous and vitreous tears [6]. In addition, it has been shown in the literature that Vit-D receptors are expressed in both retinal vascular cells and choroidal endothelial cells [7]. The relationship between the level of Vit-D and retinal-choroidal diseases has been discussed in the literature, but the pediatric patient population remains uncertain on this issue.

The choroid is a tissue with a rich vascular network. Choroid tissue comprises nerves, melanocytes, connective tissue, and extracellular fluid [8]. Today, choroidal changes caused by systemic-ocular diseases can be examined in detail by using depth imaging optical coherence tomography [EDI-OCT] in the detailed analysis of retinal-choroidal diseases. It has been reported that the retinal choroidal structure is affected in some systemic inflammatory and degenerative diseases [9, 10]. Although choroidal thickness [CT] is measured with this device, it is thought that it will indirectly provide information about choroidal blood flow. Calculation of the choroidal vascular index [CVI] is done using the OCT and is an essential parameter in evaluating the vascularity of the choroid. The ratio of the luminal area [LA] to the total area [TA] is taken as the CVI. Studies conducted in the last few years have shown that the CVI is different in those with systemic diseases affecting the vascular structures of the retina compared to healthy individuals.

The aim of the current research was to investigate quantitatively the choroidal structural parameters, which included the subfoveal CT, 1500 µm temporal CT [T1500], 3000 µm temporal [T3000], 1500 µm nasal [N1500], and 3000 µm nasal [N3000]. In addition, the evaluation of the change in the CVI before and after Vit-D replacement and the relationship of this measurement with the CT were evaluated.

## Materials and methods

### Ethics approval

This study comprised case–control and prospective research conducted at the Ophthalmology Department of a tertiary university hospital. All practices with this research adhered to the Declaration of Helsinki. The study protocol was approved by the institutional board of the local ethics committee. All of the study participants, in addition to their parents, submitted written informed consent prior to their enrollment into the study.

### Inclusion–exclusion criteria and examinations

In the current research, 168 eyes of 168 individuals, comprising 83 eyes of 83 pediatric patients who were deficient in Vit-D, as Group 1, and 85 eyes of 85 healthy age/sex-matched pediatric patients with a normal Vit-D status, as Group 2, were included for analysis. Evaluation of the serum Vit-D levels was performed via immunoassay. A plasma 25 [OH] Vit-D level measuring below 20 ng/mL was considered as a deficiency in Vit-D [11].

Group 1 was further divided into 3 subgroups based on the level of Vit-D. Those with serum a Vit-D level $\leq$ 5 ngr/mL were classified as group 1a, those with a serum Vit-D level between 6 and 15 ngr/mL were classified as group 1b, and those with a serum Vit-D level between 16 and 20 ngr/mL were classified as group 1c [12].

A Caucasian healthy pediatric group with normal Vit-D levels [between 20 and 100 ngr/mL] who met

the same criteria for inclusion and exclusion were taken as the control group [as Group 2] [12]. Inclusion criteria for all of the participants included in the study were confirmed by both a pediatric [A.A.] as well as a retinal specialist [E.A.].

Participants were not included in the study if they were < 6 years old or > 18 years old, and in the presence of various systemic diseases like hypertension, as well as autoimmune, thyroid, and heart disease. Ocular exclusion criteria were, respectively, ocular surgery, corneal pathology, trauma history, visual acuity less than 20/20, choroidal disease or optic disc disorders, refraction error that was greater than ± 1 D, axial length that was greater than 24 mm, and intraocular pressure that was greater than 21 mm Hg.

## Optical coherence tomography imaging

After the biomicroscopic examination performed by an experienced retina specialist [E.A.] on all of the participants, their measurements were taken by an experienced medical technician with the help of EDI-OCT (Spectralis, Heidelberg Engineering GmbH, Heidelberg, Germany).

All of the OCT measurements were conducted at a similar hour interval [between 9:30 and 10:30 h] so as to avoid the occurrence of physiological diurnal changes. Only high-quality images [> 25 Q] of the horizontal images taken by focusing on the foveal region following dilation of the pupils of the participants were evaluated (Fig. 1A). The views were observed and measured by using Heidelberg Eye Explorer software v.1.8.6.0 [Heidelberg Engineering, Germany].

CT measurements of the subfoveal CT, 1500 µm temporal CT (T1500), 3000 µm temporal (T3000), 1500 µm nasal (N1500) and 3000 µm nasal (N3000) regions were manually performed. The distance measured from the outside edge of the retinal pigment epithelium to the inside surface of the choroid-sclera junction was evaluated as the CT.

Lastly, choroidal vascularity was analyzed from the EDI-OCT images taken with the help of an image processing program.

## Acquisition and processing of the image

Processing of the image was done using Fiji open-source software downloaded from http://fiji.sc/.

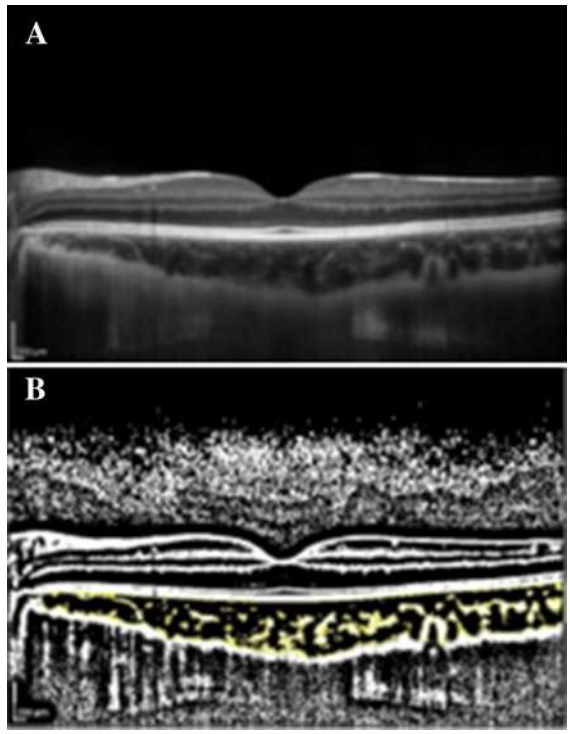


**Fig. 1** **A** Illustration of horixontal scan centered on the central fovea region in a participant. **B** Choroidal vascularity indedx measurement using imageJ software. The luminal area (dark pixels) is presented as yellow şines using the color threshold tool, and stromal area is presented bright pixels

The images that were obtained were analyzed using the method that was reported by Agrawal et al. Image J version 1.53a (National Institutes of Health, Bethesda, MD, USA) was used to view the OCT scans. As the first step, the unit of length, in µm, and pixel distance of 200 µm were designated in the set scale.15 Next, the images were converted into 8-bit type. Then, they were binarized so as to view the choroid-scleral junction by using the Niblackautolocal threshold. After that, the total choroidal area [TA], between the retinal pigment epithelium and the choroid-scleral junction, was selected using the polygon set tool. This area was then saved to the region of interest [ROI] manager. Then, the images were converted into Red–Green–Blue color type. After that, the dark pixels that expressed the luminal choroidal area [LA] were selected using the color threshold tool and that was then also added to the ROI manager. As a final step, to be able to define the area of

vascularity in the selected polygon, both of the areas in the ROI manager were selected and then merged using the 'AND' command (Fig. 1B). The ratio of the LA to the TA was expressed as the CVI. Light pixels were expressed as the SA, which was obtained by subtraction of the LA from the TA. Both the 5-point CT value and the CVI value obtained from the EDI-OCT images were measured by two researchers as double-blind.

Evaluation of the interobserver and intraobserver reliability of these measurements was performed using intraclass correlation coefficients [ICCs] with a confidence interval [CI] of 95%. ICC values that were greater than 0.75 were acceptable and values that were greater than 0.90 were accepted as excellent. Pediatric patients who were deficient in Vit-D were administered treatment with 300,000 IU of cholecalciferol orally [Devit3 I.M./Oral Ampul; Deva Holding A.S., Istanbul, Turkey]. Patients who had serum a Vit-D level above 20 ng/mL in their blood measurements at 3 months post-treatment were then re-evaluated. All of the measurements were repeated, and those taken before and after treatment were compared.

### Statistical analysis

IBM SPSS Statistics for Windows 24.0 (IBM Corp., Armonk, NY, USA) was used for all of the statistical analyses, with the data collected using the right eyes of all of the participants. Both visual methods, such as histograms and probability plots, and analytical methods, like the Kolmogorov–Smirnov and Shapiro–Wilk tests, were used to test the normality of the data. The results of the descriptive analyses were expressed as the mean and standard deviation (SD). The independent $t$ test was used in the comparison of two normally distributed groups. The paired-sample $t$ test was used in the comparison of the data pre- and post-treatment. The $x^2$ test was used in the comparison of the categorical variables. $P<0.05$ was accepted as statistically significant in all of the measurements.

## Results

The mean age of the participants in Group 1 was $12.3\pm3.74$ years, and in Group 2 it was $11.2\pm4.25$ years. Both of the groups were similar in regard to the age and sex of the participants [$P>0.05$]. The mean Vit-D value in Group 1 was $10.94\pm3.88$ ng/mL and in Group 2 it was $27.67\pm7.26$ ng/mL ($p<0.001$). Table 1 summarizes the demographic and clinical characteristics of the groups [$P>0.05$ for all of the values]. In Group 1a there were 25 patients, in Group 1b there were 29 patients, and in Group 1c there were and 29 patients. The gender and mean ages were similar between the subgroups of Group 1 ($P>0.05$ in both groups).

The subfoveal choroidal thickness [SFCT], N1500, N3000, T1500, T3000, CT, TA, LA, and CVI values in Group 1 were all statistically significantly lower when compared to those in Group 2. ($p<0.05$ for all) (Table 2).

The CT value was significantly increased at all of the measurement points after Vit-D replacement therapy [$P<0.05$ for all of the values] (Table 3). The choroidal vascular parameters of the patients before and after treatment are shown in Table 3 in detail. When we look at the subgroup analyses, there was a significant change in all of the values in Group 1a, while a significant change was observed in the vascular parameters rather than the CT in Group 1c. The detailed analysis of the CT and vascular parameters

**Table 1** Comparison of the patient demographics and clinical characteristics between the groups

BCVA: Best corrected visual acuity, IOP: Intraocular pressure, AL: Axial length, MBP: Mean blood pressure

Bold values indicate $p<0.05$

| | Patient group ($n=83$) | Control group ($n=85$) | $P$-value |
|---|---|---|---|
| Gender (female/male) | 45/38 | 43/42 | 0.705 |
| Age (years) | $12.3\pm3.74$ | $11.2\pm4.25$ | 0.102 |
| BCVA (logMAR) | $0.02\pm0.05$ | $0.04\pm0.06$ | 0.134 |
| IOP (mmHg) | $12.26\pm2.01$ | $11.94\pm1.74$ | 0.328 |
| Vit-D level (ng/mL) | $10.94\pm3.88$ | $27.67\pm7.26$ | **<0.001** |
| AL (mm) | $23.09\pm3.61$ | $22.89\pm2.98$ | 0.68 |
| MBP (mmHg) | $93.2\pm8.75$ | $92.8\pm10.65$ | 0.89 |

**Table 2** Comparison of the central macular thickness and CT values in the patient and control groups

| | Patient group ($n=83$) | Control group ($n=85$) | $P$-value* |
|---|---|---|---|
| CMT (μm) | 256.6 ± 14.72 | 254.36 ± 15.27 | 0.407 |
| SFCT (μm) | 344.85 ± 81.13 | 383.05 ± 74.22 | **0.006** |
| N1500 CT (μm) | 294.11 ± 66.55 | 320.34 ± 70.81 | **0.032** |
| N3000 CT (μm) | 225.95 ± 55.54 | 251.05 ± 73.28 | **0.032** |
| T1500 CT (μm) | 318.13 ± 75.59 | 362.84 ± 64.82 | **< 0.05** |
| T3000 CT (μm) | 299.56 ± 59.07 | 323.30 ± 72.21 | **0.045** |
| TA ($mm^2$) | 0.8230 ± 0.88 | 0.8680 ± 0.088 | **0.005** |
| LA ($mm^2$) | 0.6691 ± 0.071 | 0.7176 ± 0.087 | **0.001** |
| SA ($mm^2$) | 0.1560 ± 0.03422 | 0.1503 ± 0.04360 | 0.416 |
| CVI (%) | 0.6584 ± 0.033 | 0.6800 ± 0.077 | **0.006** |

CMT; central macular thickness, SFCT; subfoveal choroid thickness, CT; choroid thickness, N; nasal, T; Temporal, TA: Total choroidal area, LA: Luminal area, SA: Stromal area, CVI: Choroidal vascularity index

Results are denoted as the mean ± standard deviation, $n$; number of eyes

*Independent $t$ test

Bold values indicate $p < 0.05$

**Table 3** Comparison of the Vit-D level, central macular thickness, and CT values pre- and post-supplementation

| | Pre-treatment | Post-treatment | $P$-value |
|---|---|---|---|
| Vit-D level (ng/mL) | 10.63 ± 5.71 | 28.67 ± 5.29 | **< 0.001** |
| SFCT (μm) | 344.85 ± 80.79 | 383.91 ± 72.94 | **< 0.001** |
| N1500 CT (μm) | 294.11 ± 66.27 | 319.66 ± 67.18 | **0.001** |
| N3000 CT (μm) | 225.95 ± 55.31 | 253.39 ± 60.82 | **< 0.001** |
| T1500 CT (μm) | 318.13 ± 75.27 | 371.38 ± 65.17 | **< 0.001** |
| T3000 CT (μm) | 299.56 ± 58.82 | 329.11 ± 75.74 | **< 0.001** |
| TA ($mm^2$) | 0.8230 ± 0.088 | 0.8778 ± 0.074 | **< 0.001** |
| LA ($mm^2$) | 0.6691 ± 0.070 | 0.7243 ± 0.077 | **< 0.001** |
| SA ($mm^2$) | 0.1560 ± 0.034 | 0.1535 ± 0.046 | 0.684 |
| CVI (%) | 0.6584 ± 0.033 | 0.6907 ± 0.080 | **0.001** |

CMT; central macular thickness, SFCT; subfoveal choroid thickness, CT; choroid thickness, N; nasal, T; Temporal, TA; Total choroidal area, LA; Luminal area, SA; Stromal area, CVI; Choroidal vascularity index

Results are denoted as the mean ± standard deviation

*Independent $t$ test

Bold values indicate $p < 0.05$

of the participants in the Group 1 subgroups is given in Table 4.

The ICC values of the CT, as an interval, comprised an interobserver reliability of 0.926 to 0.967 and an intraobserver reliability of 0.952 to 0.989. The ICC values of the CVI comprised an interobserver reliability of 0.958 and an intraobserver reliability of 0.981.

## Discussion

Vit-D deficiency is a quite commonly seen condition, both in Turkey and in the world. In a meta-analysis, the prevalence of Vit-D deficiency was reported at a rate of 63% in Turkey [11]. The reason for this frequency is related to demographic and regional risk factors. The most important factor in Turkey is not the lack of sunlight, but the fact that we are unable to make use of sunlight adequately. For example, traditional local clothing styles and working in closed areas prevent direct exposure to sunlight. The relationship between serum Vit-D deficiency and choroidal tissue was discussed in recent studies in the literature [13]. Choroid tissue, with its rich vascular network, can be affected by systemic diseases like Vit-D deficiency and local factors [9–14]. Altered choroidal blood flow may be responsible for functional as well as structural changes in the retina. In this study, an evaluation was conducted on the effect of Vit-D deficiency on choroidal tissue and

**Table 4** Comparison of the Vit-D level, central macular thickness, and choroidal thickness values pre- and post- supplementation in the subgroups

| | Group 1a | | | Group 1b | | | Group 1c | | |
|---|---|---|---|---|---|---|---|---|---|
| | Pre | Post | *P*-value | Pre | Post | *P*-value | Pre | Post | *P*-value |
| Vit-D level (ng/mL) | 3.9 ± 0.98 | 24.1 ± 1.8 | **< 0.001** | 10.7 ± 2.7 | 27.7 ± 4.2 | **< 0.001** | 17.4 ± 1 | 34.3 ± 3.3 | **< 0.001** |
| SFCT (μm) | 349.7 ± 89.7 | 413.1 ± 48.1 | **0.001** | 333.5 ± 74 | 372.3 ± 79.6 | **0.013** | 350.6 ± 87.1 | 357.4 ± 78 | 0.646 |
| N1500 CT (μm) | 305 ± 70.2 | 340.3 ± 51.5 | **0.031** | 290.2 ± 66.8 | 303 ± 64.5 | 0.327 | 289 ± 68 | 303.7 ± 71.8 | 0.280 |
| N3000 CT (μm) | 224.7 ± 55.7 | 271.2 ± 66.7 | **0.002** | 223.6 ± 54.9 | 233.1 ± 49.6 | 0.349 | 226 ± 60.5 | 250.4 ± 65.7 | 0.068 |
| T1500 CT (μm) | 332.8 ± 83.6 | 386.3 ± 52.6 | **0.002** | 298.2 ± 69.5 | 367.5 ± 72.3 | **< 0.001** | 319.1 ± 75.8 | 356.6 ± 68.5 | **0.012** |
| T3000 CT (μm) | 311.2 ± 55.9 | 342.9 ± 63.2 | **0.026** | 281.4 ± 63 | 326.2 ± 77.8 | **0.002** | 297.6 ± 57.2 | 312.9 ± 82.7 | 0.347 |
| TA ($mm^2$) | 0.84 ± 0.08 | 0.89 ± 0.06 | **0.014** | 0.80 ± 0.07 | 0.86 ± 0.07 | **0.002** | 0.82 ± 0.10 | 0.88 ± 0.07 | **0.006** |
| LA ($mm^2$) | 0.66 ± 0.06 | 0.75 ± 0.07 | **< 0.001** | 0.65 ± 0.06 | 0.71 ± 0.08 | **< 0.001** | 0.68 ± 0.08 | 0.71 ± 0.06 | **0.046** |
| SA ($mm^2$) | 0.17 ± 0.04 | 0.13 ± 0.05 | **0.011** | 0.14 ± 0.02 | 0.14 ± 0.03 | 0.307 | 0.14 ± 0.02 | 0.17 ± 0.04 | **0.006** |
| CVI (%) | 0.63 ± 0.02 | 0.76 ± 0.07 | **< 0.001** | 0.65 ± 0.02 | 0.69 ± 0.06 | **0.017** | 0.67 ± 0.02 | 0.64 ± 0.05 | **0.010** |

Group 1a (≤ 5 ngr/mL Vit-D, severe deficiency), Group 1b (≤ 15 ngr/mL Vit-D, deficiency), and Group 1c (≤ 20 ngr/mL Vit-D, insufficiency)

SFCT; subfoveal choroid thickness, CT; choroid thickness, N; nasal, T; Temporal, TA; Total choroidal area, LA; Luminal area, SA; Stromal area, CVI; Choroidal vascularity index

Results are denoted as the mean ± standard deviation

*Independent *t* test

Bold values indicate $p < 0.05$

vascularization in the pediatric age group. We examined the effects of Vit-D deficiency on the CT and CVI. It is a matter of curiosity to what extent being deficient in Vit-D affects the CT and CVI in pediatric patients. In this context, there are 2 questions that need to be answered; Does the change in the choroid recover after Vit-D replacement? Or does it do permanent damage? This study is the first to evaluate the change in CVI after Vit-D replacement in pediatric patients who were deficient in Vit-D. This study indicated that the CT and CVI measurements in the pediatric patients who were deficient in Vit-D were significantly smaller in comparison with those in the control group. When we reappraised the patients after Vit-D supplementation, we noticed a significant increase in the CT and CVI values and this was a statistically significant difference.

One of the important findings in the current research was that the pediatric patients who were deficient Vit-D had thinner choroidal measurements. These parameters were statistically significant in the 5-point measurements. In the literature, choroidal measurements were investigated in adult and pediatric patients who were deficient in Vit-D. In their study, Oncul et al. [13] reported that they observed significant thinning in the subfoveal CT in an adult group of patients who were deficient in Vit-D, and this situation was correlated with the Vit-D level. Vural et al. [9] found statistically significant thinning in nasal choroid tissue in addition to subfoveal choroid tissue in adult patients who were deficient in Vit-D. Unlike other studies, Aydemir et al. [15] evaluated pediatric patients who were deficient in Vit-D and determined that a correlation was present between the CT measurements and Vit-D levels, and thinner choroidal measurements were obtained in the pediatric patients who were deficient in Vit-D.

Vit-D is a potent inhibitor of VEGF, which induces proliferation of vascular endothelial cells [16]. In addition, it inhibits the proliferation of vascular smooth muscle cells and reduces the vascular mitogenic response [17]. Vit-D influences the renin-angiotensin system and develops endothelial cell-dependent vasodilation [17, 18]. Vascular dysregulation in Vit-D deficiency may affect ocular blood flow as a result of dysfunction in vascular tissues [18, 19]. In long-term Vit-D deficiency, thinning of the choroidal measurements may occur. Vit-D level is another important variable. In the subgroup analyses, choroidal thinning was clearly evaluated in the group that

was severely deficient in Vit-D, while significant thinning was observed only in the temporal 1500 CT in the group that was mildly deficient in Vit-D. The clinical significance of these statistically significant results is currently unknown. There may be some association with ischemic and vascular or degenerative diseases that may occur in the retina. Studies in the literature have shown the relationship between Vit-D deficiency and age-related macular degeneration and diabetic retinopathy [20, 21]. Choroidal thinning, which develops as a result of irregularity in vascular tissues caused by a deficiency in Vit-D, might be a precursor of these diseases. Although one study found in the literature showed choroidal thinning in pediatric patients who were deficient in Vit-D, there have been no studies evaluating the CVI in the same patient group. The CVI is a new measurement used to determine choroidal structural changes that shows the ratio of the LA to the TA [22, 23]. Increased LA is seen in diseases in which intravascular spaces are enlarged and dilated choroidal vessels leak, such as polypoidal choroidal vasculopathy and central serous chorioretinopathy [24, 25]. An increase in stromal choroidal area [SA] is observed in autoinflammatory processes that affect the connective tissue in the choroid tissue outside the vascular tissue and cause edema [26, 27]. The LA is more important than the TA because the LA constitutes 60%–65% of the TA, but is not affected by factors such as the TA, such as the axial length, refractive error, IOP, or diurnal variation [28, 29]. Moreover, it was suggested that prolonged compression by the LA results in stromal atrophy in patients who have a higher TA. It should not be forgotten that the CVI is a proportional expression, for example, a high SA with a low CVI is the choroidal finding in chronic inflammatory diseases. In the current research, a significant decrease was seen in both the TA and the LA in the pediatric patients who were deficient in Vit-D. Contrary to the CT parameters, significant changes were observed in the choroidal vascular parameters in the 3 subgroups. The significant change observed in the group that was mildly deficient in Vit-D showed that the choroidal vascular parameters gave more accurate results. The LA increased more than the SA after Vit-D treatment. Since the CVI is a proportional value, an increase was observed in the groups that were severely and moderately deficient in Vit-D after treatment with Vit-D. The findings of the study should be supported by prospective studies in which pediatric patients who are deficient in Vit-D are observed for an extended length of time.

Serum Vit-D levels may show racial differences. When we look at the studies in the literature, it can be seen that the Vit-D level is higher in the Caucasian race, together with the diet, amount of melanin, and sunlight exposure factors [30, 31]. However, it may show racial differences in structural parameters in retina-choroid tissue [32]. Although the exact cause is unknown, studies have shown that the white race has a thinner CT than other races. Caucasian participants were therefore included in the current research for the above reasons. Although the sample was homogeneous, further studies with other races are needed to generalize this.

Some studies in the literature suggested that the serum Vit-D level is an indicator that is both sensitive as well as specific in some retinal diseases [33]. Although the serum Vit-D relationship is acceptable in retinal diseases, it may be more ideal to measure Vit-D in ocular fluids. One of our limitations was that there was no evidence of how long the deficiency of Vit-D had been present in the pediatric patient group. Determining the duration deficiency of Vit-D and performing a subgroup analysis can provide significant data about the relationship with retinal structural damage.

In future work, the use of swept-sourct OCT may give more accurate results and we may obtain more clinically accurate data [34]. The advantage of this study to the practical approach emphasizes the importance of supplementation with Vit-D during childhood to prevent retinal diseases that may occur in later ages.

To the best of our knowledge, this current research is the first evaluating the choroidal structural parameters of pediatric subjects who were deficient in Vit-D pre- and post-supplementation with Vit-D. In the pediatric age group who were deficient in Vit-D, thinning of the choroid and a decrease in the CVI were the most significant in the group with the greatest Vit-D deficiency.

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**Data availability** The data that support the fndings of this study are available from the corresponding author, FK, upon reasonable request.

**Declarations**

**Conflict of interest** The authors declare no conflict of interest.

**Ethical approval** All practices with this research adhered to the Declaration of Helsinki. The study protocol was approved by the institutional board of the local ethics committee.

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