

Measurement of choroidal thickness and macular thickness during and after pregnancy

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Received: 2014-03-30 Accepted: 2014-07-15

Abstract

• **AIM:** To investigate the effect of pregnancy on subfoveal choroidal thickness (SFCT) and macular thickness in both pregnant and not pregnant healthy women.

• **METHODS:** Twenty-nine healthy pregnant women in their third trimester and 36 age-matched healthy women were enrolled in a prospective, cross-sectional study. Foveal and parafoveal thickness in the four quadrants and SFCT were measured by optical coherence tomography (OCT) in the healthy pregnant women (*i.e.* study group) and healthy women (*i.e.* control group). OCT measurements were again measured 3mo after delivery in the study group.

• **RESULTS:** Mean SFCT measurements in the control group, pregnant women of the study group, and after delivery of the study group were $320.86 \pm 59.18 \mu\text{m}$, $387.97 \pm 59.91 \mu\text{m}$, and $332.40 \pm 26.03 \mu\text{m}$, respectively. There was a statistically significant difference in the mean SFCT values between pregnant women of the study group and the control group ($P = 0.000$). Foveal and parafoveal thickness values were not statistically significant in either the study or control group.

• **CONCLUSION:** SFCT increases during pregnancy and returns to normal range in the three months after delivery. Macular thickness does not show any change during pregnancy.

• **KEYWORDS:** enhanced depth imaging optical coherence tomography; pregnancy; choroidal thickness; foveal thickness

DOI:10.3980/j.issn.2222-3959.2015.02.19

Ulusoy DM, Duru N, Atas M, Altinkaynak H, Duru Z, Açmaz G. Measurement of choroidal thickness and macular thickness during and after pregnancy. *Int J Ophthalmol* 2015;8(2):321-325

INTRODUCTION

Pregnancy is a process that physiologically changes almost all organs due to changes in the vascular, immunologic, metabolic, and hormonal systems. One of the most important organs affected by these changes is the eye^[1]. Previous studies have reported the physiological effects of pregnancy on the eye and eyesight to include decreased intraocular pressure (IOP), loss in the visual field, increased corneal thickness, and altered corneal curvature^[2-5]. Furthermore, pathological changes during pregnancy that did not otherwise exist have also been reported, including central serous chorioretinopathy (CSC), for which pregnancy was reported to be a risk factor. The increased frequency of CSC has been attributed to the hyperpermeability of choroid vessels during pregnancy^[6-8].

Optical coherence tomography (OCT), primarily used to view retinal pathologies, is currently being used for choroid screening due to advances in its technology. Studies using enhanced depth imaging OCT (EDI-OCT) have shown the thickening of the choroid in patients with CSC^[9,10]. This finding suggests that the increased frequency of CSC during pregnancy is caused by physiological and pathological changes in the choroid.

To date, a few studies have used the EDI-OCT technique to measure choroidal thickness in pregnant women compared to that of nonpregnant women^[11,12]. No studies, however, have examined choroidal and macular thickness in pregnant women during and after pregnancy.

Our study thus aims to evaluate the effect of pregnancy on choroidal and macular thickness by comparing choroidal and macular thickness in women during and after pregnancy.

SUBJECTS AND METHODS

Study Population and Design This prospective comparative study was performed in the Departments of Obstetrics, Gynecology, and Ophthalmology at Kayseri Education and Research Hospital. The study followed the tenets of the Declaration of Helsinki and was approved by the

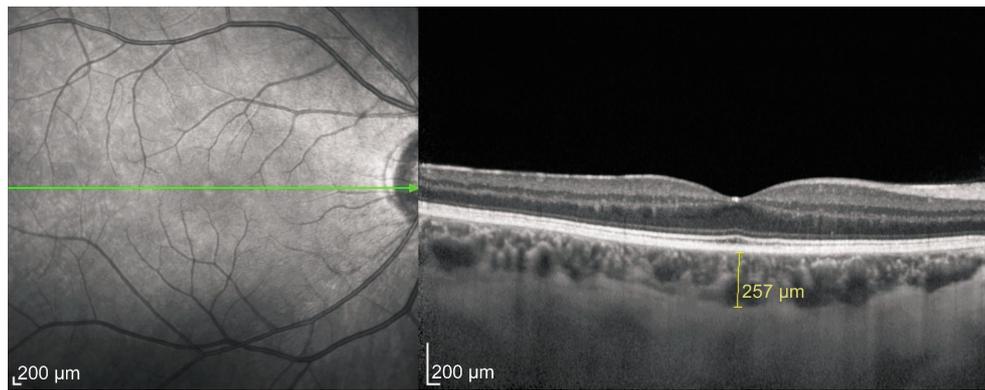


Figure 1 A typical choroidal image and the measurement points in pregnant women.

local ethics committee. All participants received both oral and written information about the study, and each participant provided written informed consent.

Participants were recruited into two groups; the study group consisted of 29 healthy pregnant women in their third trimester, while the control group consisted of 36 healthy nonpregnant women of reproductive age.

Ocular exclusion criteria for this study included prior history of significant ocular disease, a refractive error of either less than -2 diopters (D) or more than +2 D, a best corrected visual acuity (BCVA) worse than 20/20, amblyopia, IOP readings greater than 21 mm Hg, glaucoma, history of uveitis, retinal disease, ocular trauma or tumor, poor image quality, and dense media opacities.

Extraocular exclusion criteria included a history of systemic disease, such as hypertension or diabetes mellitus, and the development of complications such as gestational diabetes mellitus, preeclampsia, and pregnancy-induced hypertension in pregnant women.

Examination Protocol and Study Measurements All participants in both groups underwent a complete examination that included a Snellen BCVA, biomicroscopy, IOP measured by Goldmann applanation tonometry, and dilated fundus examination. The axial length (AL) was measured with the IOL Master 500 (Carl Zeiss Meditec Inc, Jena, Germany). Before taking OCT measurements, systolic blood pressures (SBP) and diastolic blood pressures (DBP) were measured using a sphygmomanometer (Omron Inc, Japan) with participants in the sitting position. Readings for SBP and DBP were obtained after each participant had sat for 10min. The mean arterial blood pressure (MABP) was calculated according to the formula $MABP = \frac{2}{3} DBP + \frac{1}{3} SBP$, while the ocular perfusion pressure (OPP) was calculated with $OPP = \frac{2}{3} MABP - IOP$ [13,14]. These measurements were retaken 3mo after delivery in the study group. Because of diurnal fluctuation, all examinations were performed between 9 a.m. and 11 a.m.

OCT Measurements Following this detailed ophthalmologic examination, the third-generation Spectralis

OCT device (software version 5.6.3.0; Spectralis OCT, Heidelberg Engineering, Dossenheim, Germany) was used for assessment. The method of obtaining EDI-OCT images has been previously reported [15,16]. Subfoveal choroidal thickness (SFCT) was determined as the vertical distance from the hyperreflective line of the hyperreflective retinal pigment epithelium to the line of the inner surface of the sclera centered on the fovea, which was taken using a tool with built-in linear measuring. A representative EDI-OCT choroidal image in a pregnant woman is seen in Figure 1. Images were captured by one experienced clinician and assessed by another experienced clinician. Group identities remained anonymous to both clinicians. Macular thickness was determined automatically and analyzed by OCT software. A macular thickness map was used for macular measurements. During assessments, macular thickness and volume analysis were analyzed. We selected the retinal thickness map analysis protocol on the Spectralis device to display numeric averages of the measurements for each of the five subfields, which were the central subfield (in 1 mm), inferior inner macula, nasal inner macula, superior inner macula, and temporal inner macula (in 3 mm). OCT measurements were again measured 3mo after delivery in the study group.

Statistical Analysis All statistical tests were performed using SPSS (Statistical Package for the Social Sciences) version 16. The normality of the data was confirmed using the Kolmogorov-Smirnov test ($P > 0.05$). An independent t -test was used to compare variables among study and control groups. Comparison of variables between pregnant women of the study group and after delivery of the study group were performed by a paired t -test. The categorical variables between the groups were analysed by using χ^2 test. Pearson's correlation was used to examine the relationships among the measured variables. A P value of less than 0.05 was considered significant.

RESULTS

Table 1 shows the demographic characteristics in the study and control groups. Table 2 shows the results of macular

Table 1 Demographic characteristics in healthy women and pregnant women

Variables	Healthy women (control group)	Pregnant women (study group)	<i>P</i> ^b
Number of eyes /patients	72/36	58/29	
Age (a), mean±SD (range)	28.00±5.27, (19-40)	27.41±5.48, (18-38)	0.536
Gestational age (wk), mean±SD (range)	-	31.97±3.77, (28-39)	

SD: Standart deviation. ^bIndependent Student's *t*-test.

Table 2 Evaluation of macular and choroidal thickness in control group and study group

Variables	Healthy women (control group) (n=72)	Pregnant women (study group) (n=58)	After pregnancy (study group) (n=58)	<i>P</i>		
				Healthy women vs pregnant women ^a	Healthy women vs after pregnancy ^a	Pregnant women vs after pregnancy ^b
SFCT	320.86±59.18	387.97±59.91	332.40±26.03	0.000	0.170	0.000
Foveal ^c	257.24±17.88	255.03±17.87	252.47±21.37	0.486	0.168	0.363
Superior quadrant ^d	343.67±13.41	342.78±11.37	343.40±13.02	0.688	0.908	0.751
Temporal quadrant ^d	335.26±13.07	332.57±14.71	336.47±16.70	0.271	0.646	0.094
Inferior quadrant ^d	337.51±13.82	337.10±12.13	338.57±12.64	0.859	0.654	0.379
Nasal quadrant ^d	333.32±14.84	331.79±15.11	329.90±14.04	0.564	0.183	0.456

SFCT: Subfoveal choroidal thickness. ^aIndependent Student's *t*-test; ^bPaired *t*-test; ^cMacular thickness in 1 mm field; ^dMacular thickness in 3 mm field.

Table 3 Other clinical measurements in the control group and study group

Variables	Healthy women (control group) (n=72)	During pregnancy (study group) (n=58)	After pregnancy (study group) (n=58)	<i>P</i>		
				Healthy women vs pregnant women ^a	Healthy women vs after pregnancy ^a	Pregnant women vs after pregnancy ^b
AL (mm)	22.92±0.90	23.04±0.73	23.05±0.73	0.418	0.387	0.549
IOP (mm Hg)	15.92±2.83	13.34±2.91	15.28±2.75	0.000	0.195	0.000
MABP (mm Hg)	80.17±8.64	74.79±8.39	80.34±8.14	0.001	0.905	0.000
OPP (mm Hg)	37.80±6.64	36.77±6.96	38.56±6.34	0.392	0.509	0.000
BCVA ^c	0.95±0.14	0.94±0.09	0.94±0.08	0.495	0.650	0.410

AL: Axial length; IOP: Intraocular pressure; MABP: Mean arterial blood pressure; OPP: Ocular perfusion pressure; BCVA: Best corrected visual acuity. ^aIndependent Student's *t*-test; ^bPaired *t*-test; ^cAccording to Snellen chart.

Table 4 Correlation analyses between SFCT and other clinical and demographic factors in all group

Variables	SFCT					
	Healthy women (control group)		During pregnancy (study group)		After pregnancy (study group)	
	<i>r</i>	<i>P</i> ^a	<i>r</i>	<i>P</i> ^a	<i>r</i>	<i>P</i> ^a
AL	-0.123	0.304	-0.074	0.579	0.257	0.052
IOP	0.077	0.521	0.227	0.086	0.014	0.917
MABP	-0.081	0.500	-0.116	0.386	0.028	0.833
OPP	-0.103	0.389	-0.189	0.156	0.018	0.892
BCVA	0.74	0.538	-0.48	0.723	-0.86	0.523
Age	0.038	0.752	-0.101	0.453	0.228	0.085
Gestational age	-	-	-0.035	0.792	-	-

SFCT: Subfoveal choroidal thickness; AL:Axial length; IOP: Intraocular pressure; MABP: Mean arterial blood pressure; OPP: Ocular perfusion pressure; BCVA: Best corrected visual acuity. ^aPearson correlation test.

thickness and SFCT measurements in the control group and study group. Mean SFCT measurements differed with statistical significance between the pregnant women of the study group and control group ($P=0.000$). However, the mean foveal and parafoveal macular thickness values did not differ with any statistical significance between the pregnant women of the study group and control group ($P>0.05$). There was also a statistically significant difference in the mean SFCT values between those taken during pregnancy and those taken 3mo after delivery ($P=0.000$). There was, however, no significant difference in the mean foveal and

parafoveal macular thickness measured during pregnancy and those measured 3mo after delivery ($P>0.05$). Table 3 shows the results of the other clinical measurements including AL, IOP, MABP, OPP, and BCVA in the study and control groups. Table 4 shows the correlation analyses between SFCT and other clinical and demographic factors in both groups. The SFCT value was not significantly associated with AL, IOP, MABP, OPP, BCVA or age in either the study or control group. SFCT was also not significantly associated with gestational age during pregnancy.

DISCUSSION

Pregnancy causes several physiological changes to the human body. Very important cardiovascular changes develop before, during, and after the delivery. Blood volume and erythrocyte counts increase, physiological anemia occurs, and blood pressure drops. There is also a slight increase in both the total fluid volume of the body and the intracellular fluid volume^[17]. Increased cardiac flow and volume cause an increase in ocular blood flow during pregnancy, as studies have reported^[18,19]. A high volume, from 65% to 85%, of ocular blood flows through the choroid, thus a structurally and physiologically normal choroid is important for retinal function. Thermoregulation of ocular tissues, uveoscleral aqueous drainage, regulation of intraocular pressure, and removal of waste from the eye are also performed by the choroid^[20]. The structure and thickness of the choroid can be affected by different ocular pathologies as well as systemic diseases^[21-25], hence the importance of choroidal structure assessment.

Various techniques, such as indocyanine green angiography, magnetic resonance imaging, and Doppler ultrasonography, have previously been used with various success rates while studying choroidal structures. However, none of these techniques have been able to measure choroid thickness in detail for morphological structure assessment^[26-28].

The recent development of OCT technologies has allowed more detailed choroid assessment. With a new technique called EDI-OCT, the evaluation of choroidal thickness, and morphology, studies have reported choroidal thickness to be affected by several factors. One study found that as age increases, choroidal thickness decreases^[29]. Other studies have shown that errors of refraction affect choroidal thickness, especially in case of myopia, as well as that, as the refraction degree and axial length increase, choroidal thickness decreases^[30-32].

Choroidal thickness can also be affected by ocular pathologies such as choroidal neovascular membrane, uveal effusion syndrome, CSC, Vogt-Koyanagi-Harada disease, angioid streaks, and polypoidal choroidal vascularopathy, as well as systemic diseases such as diabetes^[21-25]. However, there are a few studies about choroidal thickness in pregnant women. Takahashi *et al*'s^[11] study on 30 healthy and 30 pregnant women compared subfoveal and parafoveal choroidal thickness in both groups and found no statistically significant difference between those two groups. On the contrary, Kara *et al*'s^[12] study found statistically significant difference in SFCT between the pregnant and non-pregnant women.

By contrast, no studies have compared choroidal thickness during and after pregnancy. To the best of our knowledge, our study alone has investigated the changes in SFCT during and after pregnancy. In this study, when healthy and pregnant

women were compared in terms of choroidal thickness, the choroid was significantly thicker in pregnant women. Moreover, the same pregnant women's choroidal thickness was closer to normal range in the third month after delivery.

In other studies, choroidal thickness was found to be significantly correlated with age and axial length^[29-32]. However, in our study, there was no statistically significant correlation between choroidal thickness and age and axial length, which runs counter to the results of previous studies. This discrepancy is likely due to the fact that the age range in the study was narrow. In addition, we excluded women with high refractive errors in our study, which explains the lack of correlation between choroidal thickness and axial length. In studies using SFCT and performed on healthy individuals, IOP and OPP correlations were assessed but no significant correlations were found^[33]. In this regard our results were similar to previous studies. There were also no statistically significant correlations found between SFCT, gestational age, and MABP.

A few studies have investigated macular thickness during pregnancy. Demir *et al*^[34] have shown an increase of macular thickness in superior, inferior, and temporal quadrants, while Cankaya *et al*^[35] have reported an increase in macular thickness and volume values during the second and third trimesters.

In addition to our study's review of macular thickness, the same pregnant women were assessed 3mo after delivery in the foveal area (1 mm) and parafoveal area's (3 mm) superior, temporal, inferior, and nasal quadrants' macular thickness. There was no statistically significant difference in the foveal and parafoveal thickness in all quadrants' macular thickness when data taken during pregnancy and 3mo after delivery were compared.

In conclusion, SFCT increases in the third trimester of the pregnancy and returns to normal range in the 3mo after delivery. Otherwise, the 1 mm foveal and 3 mm parafoveal thickness in all quadrants do not show any change during pregnancy. In future studies, all changes in choroid should be assessed by EDI-OCT during the whole pregnancy period (such as 1st, 2nd and 3rd trimester) and these changes should be monitored closely for frequently seen diseases during pregnancy such as CSC.

ACKNOWLEDGEMENTS

Conflicts of Interest: Ulusoy DM, None; Duru N, None; Ataş M, None; Altınkaynak H, None; Duru Z, None; Açmaz G, None.

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