

Effect of Chronic Smoking on Choroidal Thickness as Measured by Swept Source OCT When Compared to Non Smokers

Haroon Tayyab, Sana Jahangir, Shoji Kishi

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See end of article for authors affiliations

Correspondence to:
Haroon Tayyab
ICO fellow in Vitreoretinal
Surgery
Gunma School of Medicine,
Japan

Purpose: To compare choroidal thickness between smokers and nonsmokers by utilising swept source optical coherence tomography.

Material and Methods: A total of 80 subjects were included this study. Forty patients were nonsmokers and 40 patients were smokers with a minimum history of 10 years of smoking. Swept source optical coherence tomography was used to calculate central choroidal thickness as well as choroidal thickness measurements at varying distances from centre of fovea temporally and nasally. All subjects were asked to refrain from smoking at least 8 hours before measurements.

Results: The choroidal thickness measurements did not vary between smokers and non smokers when measured on swept source optical coherence tomography. The duration of smoking also did not seem to influence choroidal thickness (p-value = 0.280).

Conclusion: Chronic smoking does not seem to influence choroidal thickness when compared to healthy non smokers.

Keywords: Swept source optical coherence tomography, choroidal thickness, smokers

Cigarette smoking is a known risk factor for causing arteriosclerotic and atherosclerotic complications in human body.¹ Similarly, smoking has also been implicated in the occurrence of various vascular ocular disorders like age related macular degeneration, central and branch retinal artery occlusion, ophthalmoplegia externa, ocular ischemic syndrome and hypertensive retinopathy.²⁻⁴

In recent times, there has been a lot of emphasis on the role of choroid in pathogenesis of various retinal disorders; especially the thickness of choroid has been in focus since the advent of optical Coherence Tomography.⁵ Cumulative evidence suggests that choroidal thickness is influenced by some physiological factors like age, gender and axial length.⁶ The main function of choroidal vasculature is to provide nutrients to outer retinal layers and enhanced depth imaging via optical coherence

tomography can help delineate choroidal structure.⁷ The progression of various chorioretinal diseases may depend on thickness of choroidal vasculature. Choroidal vascular insufficiency and decreased choroidal thickness may lead to functional impairment in retinal pigment epithelium (RPE) and photoreceptor degeneration, which may effect vision.^{8,9}

Smoking has been associated with causing vascular endothelial damage. It induces this damage by invoking oxidative stress and decreasing the levels of anti oxidants in the microenvironment of endothelial cells.¹⁰ There are a number of studies that postulate that smoking can influence retinal and choroidal vascular haemodynamics including its influence on the blood flow of optic nerve head.^{11,12} Experimental evidence has suggested that chronic smoking may be associated with altered choroidal blood flow and vascular auto regulation which may

itself be a risk factor for development of choroidal neovessels.^{13,14} Choroidal blood flow and changes in its auto regulation can alter choroidal thickness.^{4,15}

In recent times, swept source optical coherence tomography (SS-OCT) utilizing a wavelength of 1050 nm has enhanced our ability to visualize ocular structures beyond the retina and RPE. This advancement in ocular imaging technology has given us significant insight about the normality and pathology of choroid and sclera.¹⁶

In this study, we have used SS-OCT to compare the choroidal thickness in chronic smokers with non smokers with the aim to delineate the effects of smoking on choroidal thickness.

MATERIAL AND METHODS

This case control study was conducted at Department of Ophthalmology, Gunma School of Medicine, Japan from 10th January 2015 - 15th February 2015. A total of 80 volunteer subjects walking into our out door patient department (OPD) were examined in this study. An informed consent was obtained from all subjects and hospital ethical committee was informed about the nature of this study.

Forty patients were smokers and rest of them was non-smokers. Most of the patients were visiting the OPD as attendants for their relatives with ocular pathologies. Smokers with minimum 10 years of smoking were included in the study.

In this study, we included only those patients with best corrected visual acuity (BCVA) of 20/20, no ocular or systemic pathology, no history of ocular surgery or trauma, axial length of 25 mm or less and refractive error of +/- 2.50 diopters or less. It was mandatory to perform a complete ocular examination and if any pathology in structure or function of globe was noticed, the patients were excluded from the study. All patients had completely normal anterior and posterior segment examination. Male and female patients between the age of 40 and 80 years were enrolled in this study. Rest of the patients not meeting the above mentioned inclusion criteria were excluded from the study.

All subjects were instructed not to consume cigarettes or other caffeinated drinks at least 8 hours before choroidal measurements. All OCT measurements were recorded between 08:00 hrs to 12:00 hrs taking into account some recent reports of diurnal variation in choroidal thickness.

Auto refraction was performed using Automated refractometer (Nidek ARK-1, Gamagori, Japan) and axial length was calculated by using noncontact partial coherence interferometry (PCI; IOL Master, ver, 3.01; Carl Zeiss Meditec AG, Jena, Germany).

For measurement of choroidal thickness we used SS-OCT (Deep Range Imaging OCT, Topcon, Tokyo, Japan). All patients were dilated with 0.5 % tropicamide before OCT examination. For all the patients, two separate scanning protocols were followed by two experienced ophthalmic technicians. For manual calculation, a single line scan of a resolution of 3 μ m with a length of 12 mm was taken. The automated calculation was also taken with 3 μ m resolution. It followed a 3D scanning algorithm on an area of 12 x 9 mm (Fig. 1A & 1B).

For manual calculations, choroidal thickness was taken from the hyper reflective line of RPE to the outer hyper reflective line of lamina suprachoroidea. A built-in choroidal segmentation software was used to calculate choroidal thickness between the machine defined RPE and lamina suprachoroidea lines.

The mean of manual and automated readings were used for result analysis. If there were more than 15 μ m difference between manual and automated readings then automated readings were considered for analysis.

Choroidal thickness was measured at fovea and at 500 μ m, 1000 μ m, 1500 μ m and 2000 μ m nasal and temporal to fovea. Only one eye of each patient was measured.

For data analysis, SPSS Version 20.0 was used. Student t-test and Mann Whitney U test was used to compare quantitative parameters with normal and without normal distribution respectively. A p-value of less than 0.05 was considered significant while interpreting results.

RESULTS

One eye of 80 healthy volunteers was subjected to examination in this study. Forty were smokers and rest of them was non-smokers. Thirty four (42.5%) were females and 46 (57.5 %) were males. Age range was from 44 years to 78 years with mean +/- standard deviation (SD) of 58.6 +/- 9.37 years. Duration of smoking was from 10 - 40 years and number of cigarettes smoked were from half pack to 4 packs per day (one pack contains 20 cigarettes). Axial length

ranged from 21.1 mm to 24.8 mm with mean and SD of 22.68 +/- 0.80 mm.

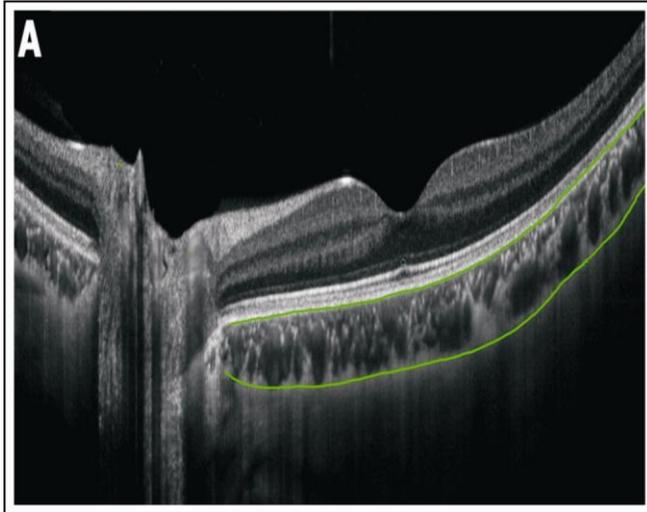


Fig. 1A: Choroidal thickness as measured by Swept Source OCT

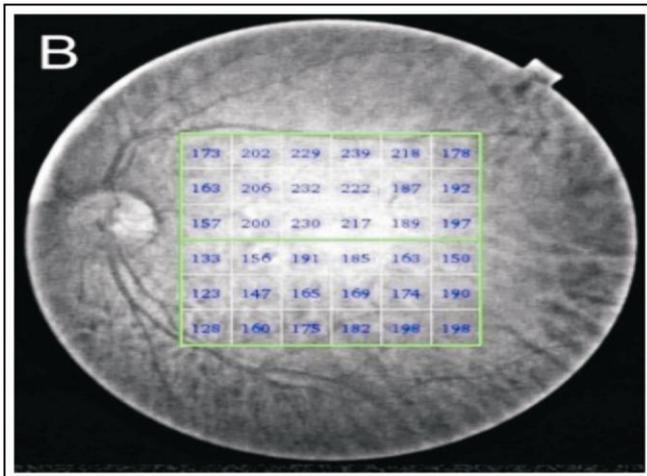


Fig. 1B: Choroidal thickness as measured

There was no statistically significant difference between smokers and non-smokers when we compared central macular thickness (CMT), central choroidal thickness (CCT) and choroidal thickness measured at varying distances nasal and temporal to foveal centre (p-value > 0.05) (Table 1).

There was no statistically significant difference in choroidal thickness between male and female patients in this study.

DISCUSSION

Choroidal thickness can vary among patients of different age groups, gender, axial length and refractive status. There have also been reports of diurnal variation in choroidal thickness¹⁷. In this study, we examined choroidal thickness among chronic smokers and compared it with that of non smokers. Patients with a history of 10-40 years of smoking were included in this study.

We found no statistically significant difference in the choroidal thickness between smokers and non smokers. Our results are similar to Dervişoğulları et al who also demonstrated no difference in choroidal thickness between smokers and non smokers; although he performed his study using spectral domain OCT (SD-OCT).¹⁸

Although Ulas, et al showed statistically significant increase in choroidal thickness when measurements were taken 5 minutes after smoking, his study also did not show any significant choroidal thickness difference measured on SD-OCT between smokers and non smokers.¹⁷ But their results were different from Sizmaz et al who reported that choroidal thickness acutely decreased once readings were taken 1 hour after smoking.⁴

To minimize the diurnal effect on choroidal thickness, we examined all the patients in morning hours of the day (0800 - 1200 hrs). Although there have been contrasting reports by Toyokawa et al and Tan et al about the effect of time of day on choroidal thickness, a report from Turkey did not report the effect of diurnal variation on choroidal thickness.^{8,19,20} These differing results can be due to different algorithms and techniques used for the measurement of choroidal thickness although most the studies did not report any change in choroidal thickness in chronic smokers.

Although various reports have shown effects of chronic smoking on choroidal blood flow auto regulation and hemodynamics of retinal vein blood flow, most of the studies have failed to show any effects of chronic smoking on choroidal thickness^{11,12}.

The weakness of this study is its cross sectional design, lack of standardization of amount of smoking in terms of "pack years of smoking", lack of evidence about different compounds in tobacco of different brands using varying concentrations of nicotine and tar (some brands may vary in the content of nicotine and tar by 500% as compared to other brands). Also we did not rule out some other known confounders of

Table 1: Comparison of choroidal and central macular thickness measured by SS-OCT with p-values

	Non Smokers (n = 90)	Smokers (n = 40)	p-value
	Mean +/- SD in Microns	Mean +/- SD in Microns	
Central Choroidal Thickness	345.67 ± 100.13	340.73 ± 78.3	0.851
500 Microns Temporal to Fovea	361.33 ± 109.42	345.23 ± 81.76	0.488
500 Microns Nasal to Fovea	343.79 ± 111.61	340.62 ± 99.43	0.715
1000 Microns Temporal to Fovea	347.34 ± 110.89	334.6 ± 91.88	0.401
1000 Microns Nasal to Fovea	326.92 ± 99.1	324.55 ± 103.21	0.771
1500 Microns Temporal in Fovea	318.44 ± 91.46	330.45 ± 106.77	0.327
1500 Microns Nasal to Fovea	301.99 ± 113.43	297.49 ± 100.57	0.829
2000 Microns Temporal to Fovea	312.34 ± 103.77	300.56 ± 84.66	0.489
2000 Microns Nasal to Fovea	261.58 ± 84.94	249.91 ± 88.43	0.544
Central Macular Thickness	223.81 ± 12.67	230.49 ± 14.66	0.237

choroidal thickness like body mass index, lipid profile and systemic blood pressure that may affect choroidal thickness at the time of examination.

The strength of this study lies in the fact that all readings were taken using SS-OCT which has a proven value for analysis of choroidal structure and is considered superior to SD-OCT for choroidal measurements, where as other studies mentioned above used SD-OCT for the same purpose²¹. Also, we used manuals and automatic algorithms and took the final average reading used in our study whereas many studies used manual method for choroidal thickness measurements. Also we emphasize on obtaining data of smokers with age matched controls.

Further studies with a better design need to be conducted to further delineate the effect of smoking on choroidal thickness. Also, better measurement algorithms may help us in the future to measure choroidal thickness with higher reproducibility.

CONCLUSION

Chronic smoking does not effect the choroidal thickness as measured on SS-OCT.

Author's Affiliation

Dr. Haroon Tayyab
ICO fellow in Vitreoretinal Surgery
Gunma School of Medicine, Japan

Dr. Sana Jahangir
Assistant Professor
Department of Ophthalmology
Sharif Medical & Dental College, Lahore
Pakistan

Prof. Shoji Kishi
Head Department of Ophthalmology
Gunma School of Medicine, Japan

Role of Authors

Dr. Haroon Tayyab
Data Collection.

Dr. Sana Jahangir
Statistics and discussion.

Prof. Shoji Kishi
OCT interpretation.

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