KASTAMONU MEDICAL JOURNAL

Original Article

DOI: 10.51271/KMJ-0135

Kastamonu Med J. 2024;4(1):21-23

Assessing the impact of internal carotid artery stenosis on choroidal thickness using cirrus optical coherence tomography

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Received: 06/02/2024 ◆ **Accepted**: 29/02/2024 ◆ **Published**: 01/03/2024

ABSTRACT

Aims: The choroid, one of the body's most highly vascularized tissues, receives its blood supply from the ophthalmic and posterior ciliary arteries, which stem from the internal carotid artery. The utilization of spectral-domain optical coherence tomography (SD-OCT) for both qualitative and quantitative assessment of the retina is increasing. The recent introduction of enhanced depth imaging OCT (EDI-OCT) has offered a novel approach to evaluate the choroid using commercially accessible SD-OCT devices. EDI-OCT enables the in vivo examination and measurement of the choroid. The main objective of our study is to evaluate choroidal thickness using EDI-OCT in patients with unilateral significant carotid stenosis; the secondary objective is to observe whether hemodynamic changes affect choroidal thickness.

Methods: The study is prospectively designed as a cross-sectional, controlled, and single-blind study, encompassing patients who underwent neck computed tomographic angiography within a one-year period due to any disease. Included patients had carotid stenosis of 50% or more on one side and less than 50% on the other side. The eyes on the side with higher carotid stenosis constituted the study group, while the other side formed the control group. Anterior and posterior segment examinations of the patients, visual acuity according to Snellen Chart, and choroidal thickness were measured.

Results: A total of 30 eyes of 15 patients were evaluated. Of the patients included in the study, 9 were men and 6 were women; the average age was 67.9 years (49-85). In the study group, the average choroidal thickness measurements were 211 µm in the nasal, 221 µm in the central and 209 µm in the temporal; in the control group, they were measured as 223 µm in the nasal, 243 µm in the central, and 231 µm in the temporal, respectively. Despite the choroidal thickness being thinner in the study group, the difference did not reach statistical significance.

Conclusion: Additional research is required to pinpoint the factors contributing to the dynamics of choroidal thickness and to delineate its significance in carotid artery stenosis more comprehensively.

Keywords: Choroidal thickness, internal carotid artery stenosis, optical coherence tomography.

INTRODUCTION

The choroid, renowned as one of the body's most extensively vascularized tissues, is nourished by the ophthalmic and posterior ciliary arteries, originating from the internal carotid artery (ICA).[1]

The use of spectral-domain optical coherence tomography (SD-OCT) for assessing the retina, both qualitatively and quantitatively, is increasing. The recent integration of enhanced depth imaging OCT (EDI-OCT) has brought a new approach to evaluating the choroid using SD-OCT devices that are readily available on the market. EDI-OCT enables the live examination and measurement of the choroid.[2,3] The main objective of our study is to evaluate choroidal thickness using OCT in patients with unilateral significant ICA stenosis; the secondary objective is to observe whether hemodynamic changes affect choroidal thickness.

METHODS

Written informed consent was obtained from all patients included in the study and the study adhered to the tenets of the Declaration of Helsinki. The study was approved by Ankara Numune Training and Research Hospital Ethics Committee (Date: 07.05.2014, Decision number: E-14-177).

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Cite this article as: Berk Ergun Ş, Asfuroğlu M, Selen F, et al. Assessing the impact of internal carotid artery stenosis on choroidal thickness using cirrus optical coherence tomography. *Kastamonu Med J.* 2024;4(1):21-23.

The research is structured as a prospective, cross-sectional, controlled, and single-blind study, involving individuals who underwent neck computed tomographic angiography over a one-year duration for any medical condition. Included participants exhibited ICA stenosis of 50% or greater on one side and less than 50% on the opposite side. The eyes corresponding to the side with higher ICA stenosis comprised the study group, whereas those on the opposite side constituted the control group. Exclusion criteria were:

1. Patients with diabetes mellitus
2. Patients with additional ocular pathologies (Glaucoma, spherical equivalent refractive error greater than 4, uveitis, age-related macular degeneration, central serous chorioretinopathy)
3. Patients with a history of vitrectomy
4. Patients with a history of ocular surgery within the last 3 months
5. Patients who received intraocular injections within the last 3 months
6. Patients with one phakic and one pseudophakic eye
7. Patients with inadequate measurement quality of choroidal thickness

Medical and ophthalmic background information was gathered from all participants enrolled in the research. Subsequently, the individuals underwent a thorough ophthalmic assessment, which involved assessing Snellen visual acuity, measuring intraocular pressure, examining the anterior segment with biomicroscopy, and conducting fundoscopy following.

In all participants, SD–OCT scans were conducted using the Cirrus Spectral Domain OCT (Carl Zeiss Meditec Inc.). The chosen scan pattern was the HRD Single Line Raster with the EDI acquisition mode, facilitating detailed choroidal imaging. Exclusion criteria included images with a signal strength ≤9. To minimize potential diurnal variations in choroidal features, EDI-OCT scans were performed between 9 am and 1 pm. Choroidal thickness was assessed as the vertical distance between two hyperreflective lines: one corresponding to the retinal pigment epithelium and the other to the inner surface of the sclera. Measurements were taken centrally at the subfoveal position and at 1,000 µm nasal and temporal to the fovea, only when the border between the choroid and sclera was clearly discernible. Images where choroidal borders were indistinct were excluded from the study cohort.

Statistical Analysis

All statistical analyses were performed using SPSS 25.0 program. The distribution of the data will be assessed with the Kolmogorov-Smirnov test. Descriptive statistics will be used for demographic data; for measurements showing normal distribution, Student's t-test will be used, and for measurements not showing normal distribution, the Mann-Whitney U test will be conducted. A p-value of less than 0.05 will be considered significant.

RESULTS

Totally 30 eyes of 15 patients who underwent computed tomographic angiography and diagnosed as a unilaterally significant ICA stenosis (one-side 50% and >50% stenotic, the other-side <50% stenotic) evaluated in this study. The mean age of the patients was 67.9±11.4. None of the patients had a history of amaurosis fugax. The mean best-corrected visual acuity (BCVA) measured with the Snellen chart was 0.747±0.29 (minimum: 0.3, maximum: 1) for the study group and 0.840±0.22 (minimum: 0.4, maximum: 1) for the control group. For statistical analysis, BCVA measured with the Snellen chart was converted to LogMAR. After conversion, the mean BCVA was 0.16±0.19 for the study group and 0.11±0.14 for the control group. No statistically significant difference was observed between the groups in terms of BCVA (p=0.346). The mean choroidal thickness values of the study and the control groups were 221.27±66.93 µm and 243.07±72.62 µm for the central area; 209.93±65.64 µm and 231.27±66.11 µm for the temporal area; and 211.73±70.44 µm and 223.01±73.77 µm for the nasal area. The values in the study group were lower than those in the control group; however, this difference was statistically nonsignificant (p=0.401 for central, p=0.383 for temporal, p=0.669 for nasal) (**Table**).

Table. Mean choroidal thickness and best corrected visual acuity values between the control and study groups

	Study group Mean±SD	Control group Mean±SD	p
Nasal CT (µm)	211.73±70.44	223.01±73.77	0.669
Central CT (µm)	221.27±66.93	243.07±72.62	0.401
Temporal CT (µm)	209.93±65.64	231.27±66.11	0.383
BCVA (LogMAR)	0.167±0.19	0.107±0.14	0.346

CT: Choroidal thickness, BCVA: Best corrected visual acuity

DISCUSSION

The ophthalmic artery, deriving from the ICA, serves as the main source of blood for the long and short posterior ciliary arteries, which are crucial for choroidal perfusion. Therefore, stenosis of the ICA could potentially affect the choroid.[4]

The utilization of SD-OCT for qualitative and quantitative assessment of the retina is on the rise. The recent introduction of EDI-OCT has provided a new avenue for evaluating the choroid using commercially available SD-OCT devices. EDI-OCT allows for the in vivo examination and measurement of the choroid.[2,3]

In this research, individuals who underwent neck computed tomographic angiography and exhibited ICA stenosis of 50% or more on one side and less than 50% on the opposite side were assessed. Despite similar anterior/posterior segment examinations and best-corrected visual acuities determined by Snellen Chart in both eyes of the participants, the study group displayed decreased choroidal thickness values compared to the control group, which is not statistically significant.

Sezgin Akcay et al.[5] investigated 21 patients with over 70% stenosis in the ICA on one side and less than 70% stenosis on the opposite side. They observed a subfoveal choroidal thickness of 231 µm on the stenotic side and 216 µm on the other side. Their hypothesis suggests that the increased subfoveal choroidal thickness on the stenotic side might be a consequence of compensatory dilatation of the choriocapillaris, aiming to mitigate ischemia resulting from reduced blood flow due to ICA stenosis.[5] While it's challenging to elucidate the reasons behind these findings diverging from our study, there are also studies in the literature that corroborate our findings.

Rabina et al.[6] observed no notable distinction in choroidal thickness between patients with ICA stenosis and controls. Sayin et al.[4] in a comparison between the eyes of 25 individuals with ICA stenosis and 25 age- and gender-matched healthy subjects, noted a reduction in choroidal thickness within the study group. In another study, Wang et al.[7] conducted a retrospective analysis of 219 patients with severe unilateral ICA stenosis, revealing a significantly diminished mean subfoveal choroidal thickness in the ICA stenosis group compared to normal eyes. They proposed that ICA stenosis might impede the blood flow in the posterior ciliary arteries, leading to inadequate perfusion of the choriocapillaris.

Various conditions and illnesses, such as age related macular degeneration and myopia resulting in a thinner choroid, or polypoidal choroidal vasculopathy leading to a thicker choroid, can induce alterations in choroidal thickness.[8-11] Noteworthy factors such as axial length, refractive error, gender, and age can influence choroidal thickness.[12-14]

In this study, the choroidal thickness of the eyes of patients with varying degrees of carotid artery stenosis on both sides was examined. Considering the presence of many physiological factors affecting choroidal thickness, comparing the two eyes of the same patient was thought to largely eliminate these factors and minimize the interaction between the factors thereby enhancing the value of the results.

One of the limitations of the study is being a single-center study with a relatively small sample size might have affected the statistical significance of findings. Secondly, in addition to choroidal structural changes, if there were examinations such as doppler ultrasonography for ocular haemodynamic changes, it could make a more detailed contribution. However, using a very special patient group to eliminate additional factors and having both study and control eyes on the same patient are both advantages of the study and reasons for the low number of cases.

In summary, this study reveals that while the choroidal thickness measured by EDI-OCT was found to be lower on the side with ipsilateral carotid stenosis across all temporal, nasal, and central choroidal thickness measurements compared with contralateral eyes, the difference did not reach statistical significance. Despite the presence of significant ICA stenosis, the choroidal thickness can remain within normal ranges. Comprehensive research is required to ascertain the factors influencing choroidal thickness either directly or via compensatory mechanisms.

CONCLUSION

Additional research is required to pinpoint the factors contributing to the dynamics of choroidal thickness and to delineate its significance in ICA stenosis more comprehensively.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Ankara Numune Training and Research Hospital Ethics Committee (Date: 07.05.2014, Decision number: E-14-177).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Financial Disclosure

The authors received no financial support for the research and/or authorship of this article.

Author Contributions

All of the authors declare that they have all participated in the design, execution and analysis of the paper and that they have approved the final version.

Acknowledgments

We would like to express our gratitude to Dr. Önder Eraslan for his contributions to the statistical analysis.

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