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Evaluation of Optic Nerve Sheath Diameter by Computerized Tomography in the Detection of Early Stage Acute Ischemic Cerebrovascular Disease

Divriklioglu Y.S.[1], Yigit Y.[2,3*], Karakayali O.[4], Yilmaz S. [5], Birinci Y.[6], Kalaycioglu B[7]

[1]Seka State of Hospital, Emergency Medicine Department, Kocaeli, Turkey
[2] Hamad Medical Corporation, Emergency Medicine Department, Qatar
[3]Blizard Institute, Queen Mary University, London, United Kingdom
[4] Sakarya University, Emergency Medicine Department, Sakarya, Turkey
[5]Kocaeli University, Emergency Medicine Department, Kocaeli , Turkey
[6] Fatih State of Hospital, Emergency Medicine Department, Trabzon, Turkey
[7]Memorial Sloan Kettering Cancer Center, Radiology Department, New York, USA

* ***Corresponding author:*** Yavuz Yigit, Hamad Medical Corporation, Emergency Medicine Department, Qatar; Blizard Institute, Queen Mary University, London, United Kingdom. Email: Yyigit@hamad.qa

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Abstract

Background: Stroke is the leading cause of high mortality rates in the emergency department (ED). In this regard, early diagnosis and starting appropriate treatments are important.
Objectives: We aimed to evaluate the efficiency of the optic nerve sheath diameter (ONSD) in the detection of ischemic cerebrovascular disease on initial brain computerized tomography (CT) images of patients presented with ischemic stroke clinic to ED.
Methods: In this study, 375 retrospectively-evaluated patients underwent brain CT with a pre-diagnosis of cerebrovascular events, following diffusion magnetic resonance imaging (MRI) due to suspicion of ischemic stroke. Demographic findings, vital signs, Glasgow Coma Scale, National Institute of Health Stroke Scale, Modified Rankin Scale. The results of brain CT as well as diffusion magnetic resonance imaging (MRI) were noted. The measurement of ONSD was done at 3 mm behind the optic disc from both eyes from the initial brain CT of the patients.
Results: In this study, 198 out of 375 patients (52.8%) were women. The mean age of patients was obtained at 67.74±13.18 years. According to diffusion MRI, 143 (38.1%) patients experienced ischemic stroke. The mean age of patients with ischemic stroke was 68.75±12.26 years, and 80 (55.9%) patients were women. The mean scores of ONSD with ischemic stroke were 5.14±0.68 and 4.79±0.6 in the control group. In the diagnosis of ischemic stroke, there was a statistically significant difference between the patient and control groups in terms of ONSD.
Conclusion: In CT images of patients with ischemic stroke, ONSD values were found to increase. If ONSD measurement via brain CT correlates with physical examination and clinical signs, it can be used as an indicator in the diagnosis of early-term ischemic stroke.

Keywords: Brain tomography, Ischemic stroke, Optic nerve sheath diameter

1. Background

Stroke is a syndrome consisting of symptoms and signs showing rapidly progressive focal loss of cerebral function due to vascular causes. Cerebrovascular diseases (CVDs) occupy the second place with a frequency of 25.2% in terms of the total deaths in Turkey and are in the third place with 5.9% in the calculations of Disability Adjusted Life Years (1). Stroke is becoming an increasingly important public health issue due to the psychosocial problems emerging following a stroke, the need for care of the patient, and the economic losses it brings.

The most commonly used method in the diagnosis of stroke is brain computed tomography (CT) without contrast, which can be easily accessed and applied quickly. Although brain CT might be normal in the first hours of ischemia, it helps to make the differential diagnosis of intracerebral hemorrhage, tumor, abscess, or trauma 3 h after ischemia. Changes due to decreased density begin to appear in the brain parenchyma and the ischemia area becomes evident in 24-48 h. When brain CT scans taken in the first 3 h are carefully examined, early signs of stroke can be seen in 67% of the cases; however, in the acute phase, CT scans have a low sensitivity in demonstrating classical findings of stroke (2). Magnetic resonance imaging (MRI) can show parenchymal disorders in more detail and reveal small lesions in the diagnosis of acute ischemic stroke. Diffusion MRI is the imaging method that is preferred and has the highest reliability in stroke today (3). Nonetheless, the expensive nature, limited accessibility, and time-consuming examination process of MRI restrict its usage. Therefore, there is a need for alternative methods in the diagnosis of acute ischemic stroke in centers where access to MRI is limited.

sentence"Brain edema, cerebral blood volume increase, intracranial cerebrospinal fluid (CSF) increase, and the highest reliability in stroke today (3). However, the expensiveness of MRI, its restricted accessibility, and increased intracranial pressure (ICP) can significantly reduce mortality and morbidity."this part will be removed, instead""Brain oedema, cerebral blood volume increase, intracranial cerebrospinal fluid (CSF) increase and mass lesions can cause an increase in ICP. Accurate and rapid evaluation of ICP in patients with acute stroke, and early diagnosis of increased ICP can significantly reduce mortality and morbidity." will be put. However, the expensiveness of MRI, its restricted accessibility, and increased intracranial pressure (ICP) can significantly reduce mortality and morbidity. One of the non-invasive diagnostic methods used in the diagnosis of increased ICP is optic nerve sheath diameter (ONSD) measurement. Increased ICP leads to CSF flowing into the perineural subarachnoid space, resulting in increased pressure around the optic nerve. This results in the enlargement of the dural sheath and a rise in ONSD (4). Human studies show that this change occurs within minutes in case of increased ICP (5).

Optic nerve sheath diameter measurement can be made with bedside ultrasonography (USG), CT, or MRI. The reliability of ONSD measured by USG has been demonstrated in studies; however, the fact that the practicing physician must be experienced in this field to obtain a good image curtails the widespread use of this method (6). Nevertheless, ONSD measurements with brain tomography give more objective and reliable results compared to measurements with USG. In a study, it was shown that the measurement of ONSD in brain tomography is sensitive in showing the increase in intracranial pressure, and it has a similar correlation with USG and ONSD measurement. Measurement of ONSD with brain tomography gives more objective results in a user-dependent experience compared to USG. Measurement of ONSD with brain CT is an easy-to-learn and applicable method. In patients presenting with stroke symptoms, a brain CT scan is performed to rule out hemorrhage, and the fact that it does not incur any additional cost while measuring is a significant advantage.

This study aimed to evaluate the effectiveness of ONSD in the detection of ischemic CVD in initial brain CT images in patients who presented to the emergency department with an ischemic stroke clinic.

2. Objectives

We aimed to evaluate the efficiency of the optic nerve sheath diameter (ONSD) in the detection of ischemic cerebrovascular disease on initial brain computerized tomography (CT) images of patients presented with ischemic stroke clinic to ED.

3. Methods

3.1 Study Design

The statistical population consisted of patients who applied to the Tertiary Training and Research Hospital Emergency Department between January 1, 2017, and December 31, 2017. The patients with a prediagnosis of CVD, a brain tomography showing no acute pathology, and diffusion MRI after suspicion were included. The records of these patients were reviewed retrospectively. Patient information was obtained from the hospital archive, emergency department triage, and patient follow-up form files, as well as from the data system used in our hospital. The study was approved by the local Non-Interventional Clinical Research Ethics Committee with the date of 27.06.2018 and decision number 2018/206.

Inclusion criteria were an age of over 18 years, presenting with complaints that might suggest cerebral vascular occlusion (e.g., speech disorder, dizziness, nausea, vomiting, unilateral numbness, incontinence, and a change in consciousness), brain CT showing no acute infarction, undergoing diffusion MRI in the follow-up of non-diagnostic CT results. On the other hand, patients under 18 years of age, with acute infarct findings in brain tomography, who underwent direct diffusion MRI without a brain tomography, had hemorrhagic stroke in brain CT or diffusion MRI examination, did not undergo diffusion MRI, and those whose imaging techniques were performed in an external center and optic nerve diameter could not be measured in brain tomography sections were excluded from the study.

3.2. Material-Method

A data collection form was used to collect the data in a standard way. Using this form, the demographic data, the date and time of admission to the emergency department, the complaint of admission and the onset time of these complaints, the history, vital signs, admission Glasgow Coma Scale, admission National Institute of Health Stroke Scale score, Modified Rankin Scale score, admission motor examination, admission pathological reflex examination, admission brain CT, and diffusion MRI findings of patients were recorded from patient files during the study.

3.3 Imaging

Brain Tomography:

Brain CT scans taken during the diagnostic procedures were performed while the patients were in the supine position when they were admitted to the emergency department.

Brain tomography images of the patients were made by examining the Siemens Somatom Definition AS+ brand device with 128 slices. The radiological images of the patients from the hospital radiology data processing center were examined by a radiology specialist and the principal investigator with at least 5 years of experience. Patients with signs of ischemic stroke in the examination of all sections were excluded from the study.

ONSD measurement:

Right and left ONSD radiological measurements of the cases were performed in the axial plane of the brain CT images, 3 mm behind the optic disc exit in the sections where the optic nerve sheath was visualized

(Figure 1-2). Both optic nerve diameters were measured separately, and the average value of the right and left optic nerve diameters was calculated and recorded. Patients who could not be measured in the axial plane were excluded from the study. All measurements were evaluated by a radiologist with at least 10 years of experience.

Diffusion MRI:

Patients who lacked acute pathology in brain tomography and who underwent diffusion MRI for further investigation were included in the study. All recordings were made using a 1.5 tesla Siemens Amira Syngo MR device. The radiological images of the patients from the hospital radiology data processing center were examined by a radiology specialist and the principal investigator with at least 5 years of experience. The patients were categorized into two groups according to the diffusion MRI findings in the follow-up. Group 1 consisted of patients with normal brain CT findings and normal diffusion MRI findings, while group 2 patients included normal brain CT findings and acute infarction detected on diffusion MRI. Ischemic areas and localizations of patients with ischemic CVD were recorded according to diffusion MRI images.

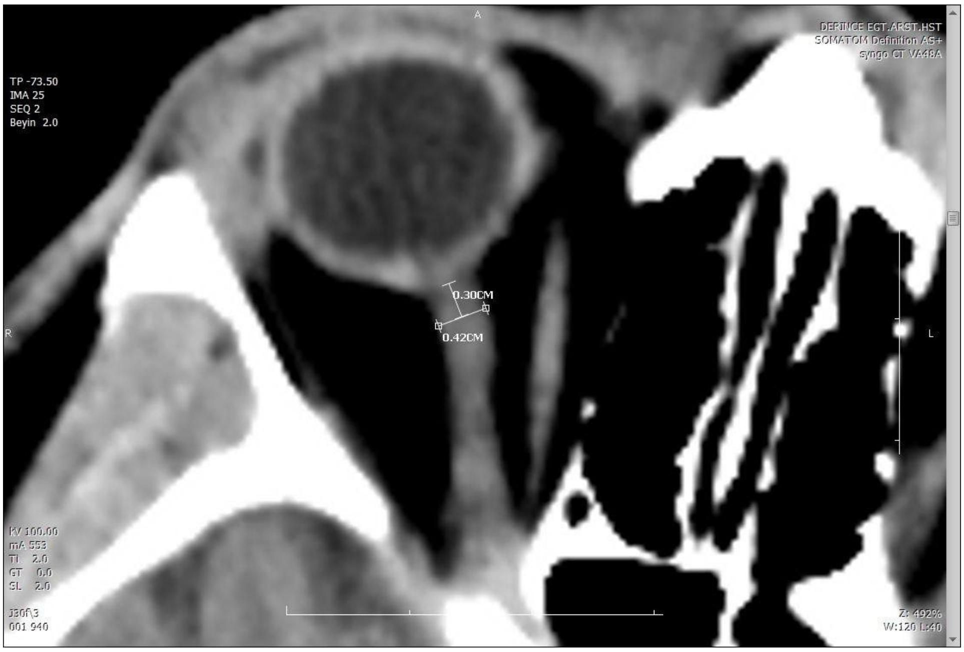

Figure 1. Right optic nerve diameter measurement

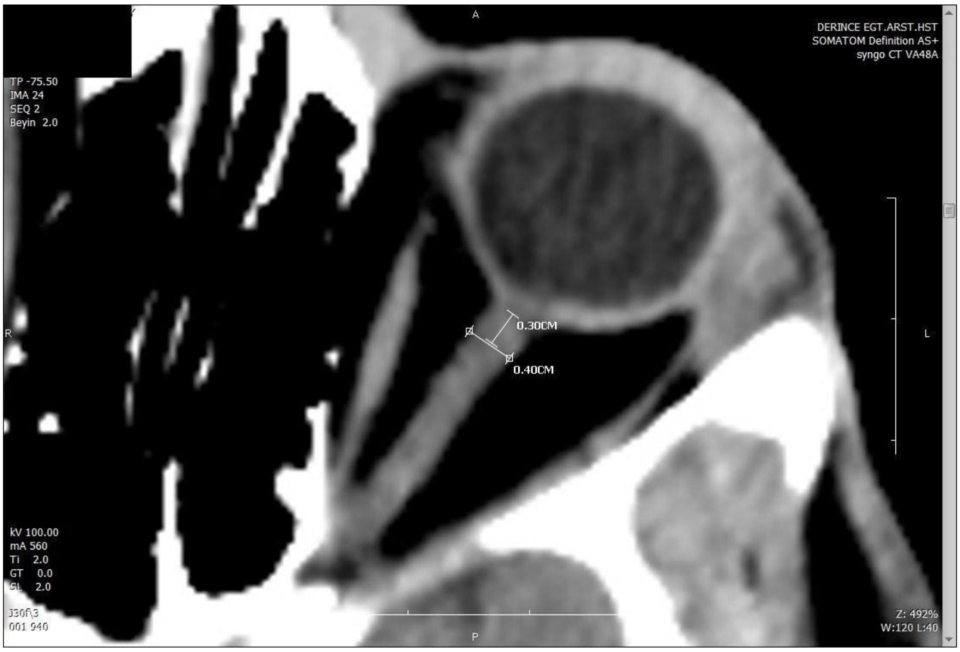

Figure 2. Left optic nerve diameter measurement

3.4. Statistical Analysis

The data of the study were analyzed using the SPSS software (version 20.0). The data of the study were presented as mean ± standard deviation, number, and percentage values. ONSD parameters measured by brain CT were analyzed primarily in terms of their compatibility with normal distribution in groups with and without ischemia. The Kolmogorov-Smirnov normality test was used in the analysis, along with normal distribution fit graphs. Student t-test was utilized to compare normally distributed variables, and the Mann-Whitney U test was used to analyze independent data that did not fit normally.

Study receiver operating characteristic (ROC) curves were drawn and the area under the curve was used to determine the performance of enhanced ONSD to predict CVD. In addition, after determining the best cut-off value from the graphical data, sensitivity and specificity were calculated with 95% concordance intervals. The p-value of less than 0.05 obtained in the statistical evaluation was considered significant.

4. Results

Patients who were admitted to the emergency medicine clinic between 01.01.2017 and 31.12.2017 with a prediagnosis of ischemic CVD, no acute pathology detected after the brain CT scan, and diffusion MRI performed after the clinical prediagnosis continued were included in the study by reviewing hospital data records. A total of 465 consecutive patients who underwent diffusion MRI with normal brain CT were evaluated. Among this population, 30 patients whose data could not be obtained from the patient clinical files; 6 patients who underwent diffusion MRI in an external center; 28 patients with a history of previous ischemic or hemorrhagic CVD, intracranial mass, or CNS infection that might affect the known optic nerve diameter; 12 patients with a primary clinical diagnosis other than CVD and hospitalization in other clinics; 8 patients whose optic nerve diameter could not be measured on brain CT images; and 6 patients with hemorrhagic CVD were excluded from the study. Finally, 375 patient results were analyzed.

The mean age of the patients included in the study was obtained at 67.74±13.18 years. Females accounted for 52.8% (n=198) of all patients. Ischemic CVD was detected in 143 (38.1%) patients in the study group who were not diagnosed with acute pathology in brain CT and who underwent diffusion MRI due to the persistence of clinical suspicion of prediagnosis. The mean age of patients with ischemic CVD was 68.75±12.26 years, and 55.9% (n=80) of the cases in this group were women. No statistically significant difference was found between the patient group with ischemic left ventricular hypertrophy detected by diffusion MRI findings and the patient groups without ischemia in terms of age and gender (P=0.242 and P=0.338, respectively) (Table 1).

Examining the interval between clinical symptom onset and admission to the emergency medicine clinic, the mean duration of admission for all patients was 97.59±95.21 min (minimum: 10 min, maximum: 540 min). According to diffusion MRI findings, the mean time to admission was 97.12±95.78 min in patients whose ischemic CVD could not be detected, and 98.08±95.29 min in the group with ischemic CVD. There was no statistically significant difference between the two groups in admission times (P=0.951).

When patients with a preliminary diagnosis of ischemic CVD without acute pathology in brain CT and who underwent diffusion MRI with advanced imaging, diffusion MRI was normal in 232 patients (61.9%), while ischemic CVD was detected in 143 patients (38.1%). Ischemic CVD was detected in the right brain region in 65 (17.3%), 69 (18.4%) patients in the left brain region, and in 8 patients (2.1%) in both regions of the brain.

4.1. Main results

The mean value of optic nerve diameters measured on brain tomography was 5.14±0.68, in patients with ischemia and 4.79±0.6 in patients without ischemia. The mean values of right and left optic nerve diameter were 4.93 5±0.67 and 4.90±0.69, respectively. According to diffusion MRI findings, the mean value of left optic nerve diameter

Table 1. Distribution of patients' admission vital signs and scoring systems according to study groups

	CVD (-) (n=232)	CVD (+) (n=143)	All patients (n=375)	P
Systolic Arterial Pressure (mean±SD)	129.7±30.9	142.63±32.26	134.63±32	<0.05
Diastolic Arterial Pressure (mean±SD)	75±16	82.03±14.71	77.68±15.86	<0.05
Pulse (mean±SD)	86.24±19.88	84±19.04	85.39±19.57	0.282
GCS (mean±SD)	14.64±1.4	14.2±1.97	14.47±1.65	0.011
NIHS (mean±SD)	0.49±1.77	5±5.61	2.2±4.32	<0.05
Modified Rankin Scale (mean±SD)	0.23±0.83	2±1.72	0.9±1.51	<0.05

CVD: Cerebrovascular disease, NIHS: National Institutes of Health Stroke Scale, GCS: Glasgow Coma Score in patients with ischemic CVD was 5.12±0.71, while right optic nerve diameter was 5.14±0.7. In patients without ischemic CVD, the left optic nerve diameter was 4.77±0.64, whereas the right optic nerve diameter was 4.82±0.61. A statistically significant difference was observed between optic nerve diameters in the detection of ischemic CVD (P=0.017) (for optic nerve mean diameter, P=0.016 for right optic nerve diameter, P=0.042 for left optic nerve diameter) (Table 2).

The ROC curve showing the estimation of ischemic CVD by optic nerve diameter is illustrated in Figure 3. The area under the curve for optic nerve diameter was 0.652 (95% CI: 0.59-0.71). Sensitivity, specificity, negative predictive value, positive predictive value, positive likelihood ratio, and negative likelihood ratio for different cut-off values of optic nerve diameters are presented in Table 3.

Table 2. Distribution of ONSD by study groups

	Ischemic cerebrovascular disease (-)	Ischemic cerebrovascular disease (+)	P
Optic nerve mean diameter	4.79±0.6	5.14±0.68	0.017
Right optic nerve diameter	4.80±0.61	5.14±0.7	0.016
Left optic nerve diameter	4.77±0.64	5.13±0.71	0.042

Table 3. Analysis of sensitivity and specificity at different cut-off values of ONSD

ONSD	Sensitivity %	Specificity %	PPV %	NPV %	LR +	LR -
ONSD>4	96.5	57.8	38.7	73.6	2.23	0.17
ONSD>4.5	81.1	32.7	42.6	73.7	1.19	0.59
ONSD>5	57.3	65.9	50.9	71.4	1.62	0.66
ONSD>5.5	27.9	90.9	65.5	67.1	2.7	0.7
ONSD>6	11.1	97.8	76.1	64.1	3.6	0.9
ONSD>6.5	2.1	98.7	50	62	1	0.65

ONSD: Optic nerve sheath diameter, PPV: Positive predictive value, NPV: Negative predictive value, LR: Likelihood ratio

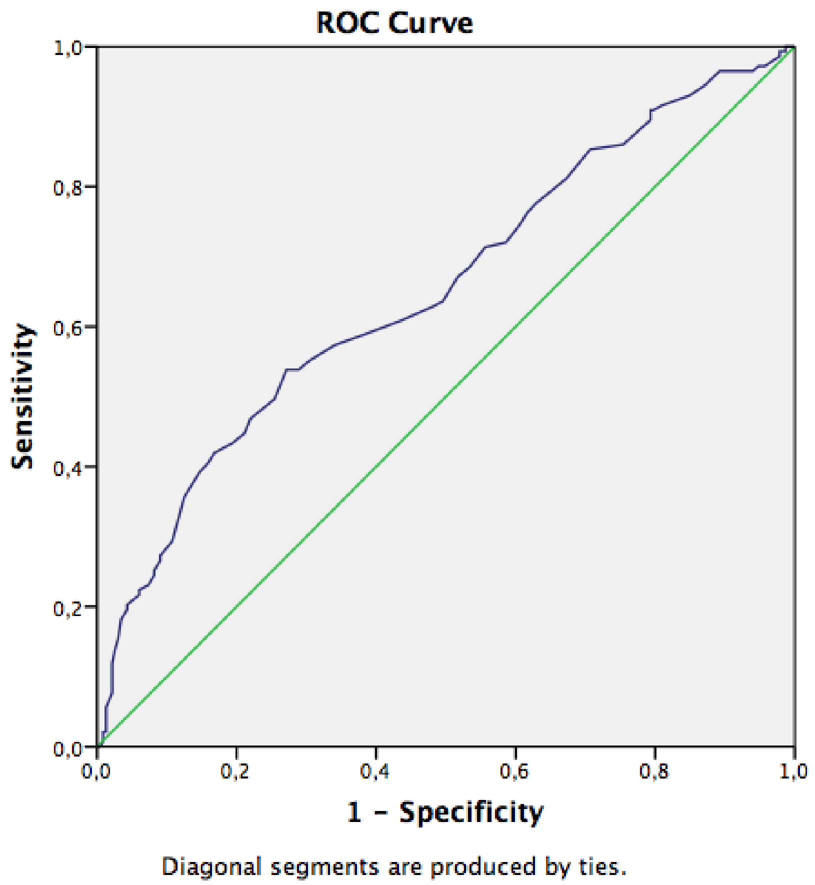

Figure 3. ROC analysis of ONSD in the detection of ischemia CVD

When the final status of the patients was examined after the first examination, 242 patients (64.5%) were discharged from the emergency department, 118 patients (31.5%) were hospitalized in the neurology clinic, and 14 patients (3.7%) were hospitalized in the intensive care unit.

5. Discussion

Ischemic stroke can also present with cytotoxic edema, developed as a result of physiopathological and mechanical damage to the cell membrane or increased ICP due to edema developing in the infarcted tissue. Accurate and rapid evaluation of ICP in patients with acute ischemic stroke and early diagnosis of increased ICP can significantly reduce mortality and morbidity (7, 8).

Kimberly et al. reported in their study that there was a direct relationship between ONSD and ICP (9). Literature review shows an increase in ICP by measuring ONSD with non-invasive methods (10). In our study, a statistically significant difference was found between optic nerve diameters in the detection of ischemic CVD (P=0.017 for the mean ONSD, P=0.016 for the right ONSD, P=0.042 for the left ONSD).

In a study conducted by Bekerman et al., an increase in ONSD was observed in 94.3% of the cases experiencing a rise in ICP; this value was calculated as 6.2±1.2 mm in the right ONSD and 6.3±0.9 mm in the left ONSD (11). In a study by Gökcen et al., patients with ischemic CVD were examined according to the subgroups of the Oxfordshire Community Stroke Project classification. Among the 191 patients, 99 were included in the study group and 92 in the control group, and the ONSDs of the patients were evaluated with CT scans. When ischemic CVD subgroups were compared with the control group in terms of increase in right and left ONSD, a statistically significant difference was found between all ischemic CVD subgroups and the control group (11).

ONSD measurement can be made with bedside USG, CT, or MRI (12). Among these methods, bedside USG is the most cost-efficient and easily accessible method. However, the experience of the physician performing the application is an important factor affecting the achievement of correct results. Among the disadvantages of MRI are long scan times, high costs, limited access, and incompatibility with pacemakers and metal implants.

However, measurement of ONSD with brain CT is an easy-to-learn and applicable method. It is more advantageous than USG as it allows the measurement of ONSD with a high-resolution image (13). A brain CT scan is performed to rule out hemorrhage in patients presenting with stroke; one of the important advantages of this method is that it does not impose any additional cost while measuring.

6. Conclusion

Consistent with the results of similar studies reported in the literature, in our study, there was a significant difference detected between right and left mean ONSD measurement values of the control group patients who lacked acute pathology in brain CT and who had ischemic CVD as a result of diffusion MRI because the clinical suspicion of preliminary diagnosis continued.

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None.

Footnotes

Conflicts of Interest: The authors declare no conflicts of interest.

Author Contribution: The authors contributed equally to this work.

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Ethical Statements: This study was approved by the local Non-Interventional Clinical Research Ethics Committee with the date of 27.06.2018 and decision number 2018/206.

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