

Impact of Diabetes on Optic Nerve and Optic Nerve Sheath Measurement: MRI based study

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ABSTRACT : The aim of this study was to study the impact of the diabetic in optic nerve measurement by using magnetic resonance imaging (MRI).

MR images closed magnet, (Signa high definition (HD) with magnetic field strength 1.5T (General Electric (GE), USA) was used. The axial T2-weighted turbo spin-echo fat-suppressed sequence was used to measure optic nerve sheath diameter (ONSD) and optic nerve diameter (OND).

The sample was divided into two groups: Group 1 including one hundred was considered as control, males were 45% and females were 55%. Their ages were between (18-80) years old with mean $39.46 \text{ years} \pm 15.81$. Group 2 including fifty diabetic patients. MRI exams were done for right and left optic nerves and optic sheath. Males were 52% and female were 48%. Their age ranged from 23-84 years old with mean age of $59.4 \text{ years} \pm 13.7$.

The study revealed a reference values measured in axial MRIs for OND was 3.05 ± 0.23 for the right side and 3.05 ± 0.22 for the left side , The mean ONSD in the diabetic group was $5.03 \pm 0.53 \text{ mm}$ for the right, and 5.08 ± 0.48 for the left ,and showed no difference from that in control group $p = 0.795$ and 0.742 respectively.

The study indicated that MR OND measurements in diabetic patients differ from the reference values that have been read from normal in the control group .There is significant deference between measurement done for the optic nerves diameters between diabetic and control group. $p=0.000$.linear relationship between the duration of diabetic with right and left optic nerve diameter measurements was found.

The study concluded that diabetes affected the OND and it was significantly decreased than that in healthy controls.

New equations were established for the prediction of the OND changes in patients with known duration of diabetics for both right and left optic nerves

Keywords - optic nerve sheath diameter; optic nerve diameter; magnetic resonance imaging

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I. Introduction

The optic nerve (ON) is the nerve of vision, it enters the orbit from the middle cranial fossa by passing through the optic canal; it is recognized as cranial nerve II. Nerve cells arise from the optic retina and converge toward the posterior aspect of the eye. These fibers unite to form the large optic nerve that passes posteromedially through the optic canal into the middle cranial fossa to join its partner at the optic chiasm. Posterior to the optic chiasm, the optic nerve extended as optic tracts that continue around the midbrain.[1]

Diabetes is not a single disease but the pathological and metabolic state caused by inadequate insulin action. [2] It is characterized by tendency to hyperglycemia and to development of atherosclerosis, retinopathy, neuropathy and nephropathy and it is major factor for coronary heart disease.[3]

Visual problems are associated with brain, endocrine, and other systemic disorders [4].For this reason, measuring the optic pathway can be a critical diagnostic tool and predictor for many neuro and endocrine pathologies.

Optic nerve sheath diameter (ONSD) is important because the optic nerve is surrounded by subarachnoidal cerebrospinal fluid and all three meningeal layers and changing of the ONSD can indicate some changes of the intracranial pressure. It was postulated that the presence of enlarged optic nerve sheaths suggests that raised intracranial pressure is transmitted to the perineural subarachnoid space. [5,6]

In normal subjects, the subarachnoid space is widest behind the globe, then narrowed toward the orbital apex [7]. The study of ONSD in the intracranial pressure monitoring is not yet been completed [8].As well, the enlargement of ONSD behind the globe at the position recommended for the ONSD measurements in cases of raised intracranial pressure was found also in papilledema, optic nerve lesions, optic atrophy, and endocrine orbitopathy.[9,10]

Increased optic nerve sheath diameter is implicated in increased idiopathic intracranial hypertension. [11] Beyond the optic sheath, variations in optic pathway measurements are also involved in many disorders. Small optic pathways indicative for septo-optic dysplasia. [12-14] A large optic pathway on the other hand may be indicative of glioma, meningioma, lymphoma, or hemorrhage. Ischemia due to cerebrovascular disease may also cause decreased optic chiasm measurements. [12]

Nerve fiber layer thickness decreases with the development of diabetic and with impairment of metabolic regulation. This finding may impact the evaluation of nerve fiber layer in diabetic patients [15] Measuring the OND and ONSD in diabetic patients is important in order to predict early the development of clinical neuro or retinopathy. Therefore the current study addresses this issue by studying optic pathway measurements in both normal and diabetic patients through analysis of axial brain MRIs, which allow for visualization of the entire optic pathway, as well to correlate the results with the duration of diabetes. The analysis of optic pathways has allowed for creating a reference point for normal measurements as well for prediction of diabetes impact on the ON and ONSD diameters through the new established equations created for optic pathway measurements in diabetics.

II. Materials And Methods

Control Group. The control group composed of normal subject with range of age was (18 – 80) years old and with different genders. Who underwent to brain MR imaging for various reasons (such as headaches, blurring vision ...etc) but had no diabetes or hypertension. And their results were interpreted as normal by an expert radiologist. Additional exclusion criteria were a history of any of the following: intracranial neoplasm, cranial deformity, invasive cranial procedures, and any orbital- or optic-related impairment. The diabetic group composed of patients with range of age was (23 – 84) years old and with different genders. Who were diagnosed to have diabetic disease and they were under treatment. This study was performed in Sudan, during the period of January 2015 up to 2018.

Each of the patients (control and diabetic) underwent an MR imaging examination in our institution. The patient lies supine on the examination couch. Both orbits are usually examined at the same time. The head coils are used, the patient assumes a fixed gaze, straight ahead, with the eye open. MR images closed magnet, 1.5T, (Signa high definition (H D) with magnetic field strength). (General Electric (GE), USA). Head coil were used the axial T2-weighted turbo spin-echo fat-suppressed sequence was used to measure ONSD and OND. The scan parameters were as follows: repetition time 3500, echo time 86.6/Ef, slice thickness 3 mm, spacing between slices 0.0 mm, field of view 16*16 and matrix is 320*224. The optic nerve sheath appeared as a high signal surrounding a region of low signal corresponding to the optic nerve. The axial image slice that provided the best view of the ONSD was used. The retrobulbar area was zoomed to 300*300, and then ONSD and OND were measured in an axis perpendicular to the optic nerve, 3 mm behind the globe using an electronic caliper. The OND and the ONSD values obtained from both sides were averaged for comparison with standard range of optic nerve.

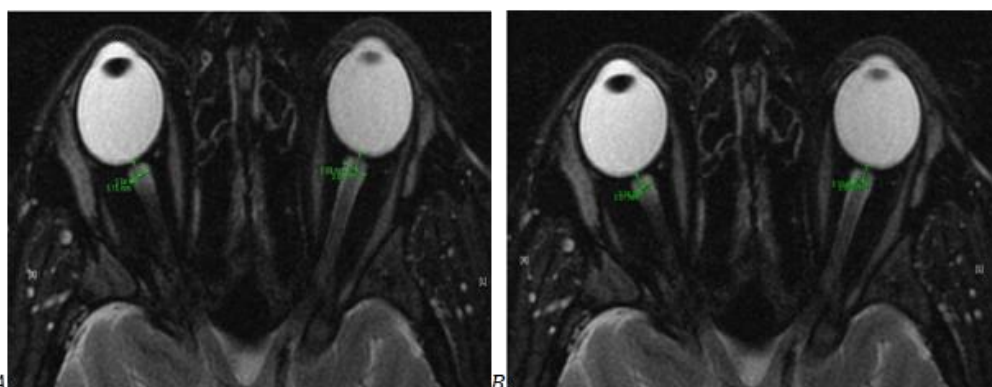


Fig.1 Example of measurement method; A.ONSD 3mm behind globe, B.OND 3mm behind globe.

III. Results

The one hundred fifty patients were studied. The one hundred were control and fifty patients with diabetic disease. All patients were right and left ONSD and OND measurements were taken. The mean width of the optic nerve sheath and optic nerve diameter was calculated separately for the controls and patients with diabetic disease within each age group. And all measurement was analyzed by using the Excel program and SSPS. And the difference between the control and diabetic group were analyzed by using independent-sample t tests. The difference in the Two groups for both RT and LT sides was done using the Pearson correlation test.

Values are expressed as means ± standard deviation otherwise specified, and P values was calculated to show if there is any significant impact of each variable variation, at P - values < 0.05 were considered to be statistically significant.

Table (1) shows the ONSD and OND for both RT and LT sides in the two examined study groups

Groups statistics	Variables to be	Side	Diabetic \ Control	N	Mean	Std. Deviation	T	P_ value
Measured ONSD 3mm		RT	Diabetic	50	5.03	.53	-.260	.795
			control	100	5.05	.34	-.227	
ONS D 3mm		LT	Diabetic	50	5.08	.48	.330	.742
			control	100	5.06	.35	.298	
OND 3mm		RT	Diabetic	50	2.49	.27	-13.189	.000
			control	100	3.05	.23	-12.494	
OND 3mm		LT	Diabetic	50	2.46	.23	-14.644	.000
			control	100	3.05	.22	-14.413	

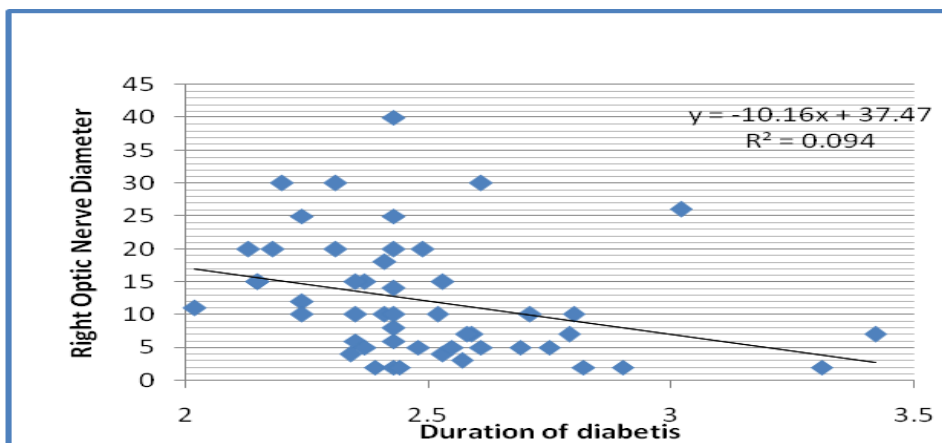


Fig.2 scatter plot diagramme shows the linear relationship between the duration of diabetic and right optic nerve measurement, when the duration of diabetic increased the measurement decreased by -10.16 starting from 37.47 $r^2 = 0.094$

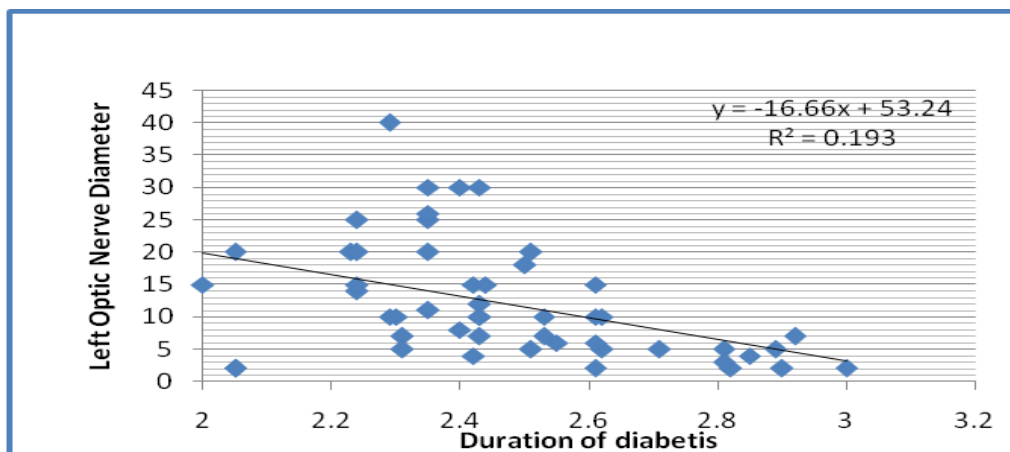


Fig.3 scatter plot diagramme shows the linear relationship between the duration of diabetic and left optic nerve measurement, when the duration of diabetic increased the measurement decreased by -16.66 starting from 53.24 $r^2 = 0.193$.

IV. Discussion And Conclusion

Measuring the ONSD is important because it covers an important anatomy which is the optic nerve, and changing of the ONSD can be as an indicator of some pathological changes [5,6]

Analyzing the main findings obtained; firstly we will discuss the fact of using the 3 mm distance from the globe as an ideal location to measure ONSD .Anatomically it was found that the sheath is normally found to be loose near the eyeball, with a much bigger space between the optic nerve and the sheath than anywhere else in its course, thus presenting bulbous form behind the eyeball [16]. This fact is confirmed up-to-date [17].This

was found to ease the movement of optic nerve's head while moving with the eye. Further histologic studies revealed a segment of the optic nerve in which maximal diameter fluctuations could be expected, namely the bulging dura mater region around 3 mm behind the papilla [18]. This position was recommended for the ONSD measurements for monitoring many diseases and this was used in many studies [19, 20]. We apply ONSD at that point for monitoring and evaluating the ON and ONS in both normal and diabetes groups, because studies have mentioned that, the enlargement of ONSD behind the globe at the position recommended for the ONSD measurements in cases of raised intracranial pressure was found also in papilledema, optic nerve lesions, optic atrophy, and endocrine orbitopathy [21,22][9,10]

Different authors estimated the ONSD at different distances from the globe measuring it 3 mm [21],[22], 4mm[19], 2 to 5 mm behind the globe or even not mentioning this distance at all[23],[24]. In 1996, Helmke and Hansen[25] presented their explanation of how to choose the specific distance for the measurement. These authors found that at 3 mm distance from the globe, the ONSD experienced wider changes than in other intraorbital sections of the optic nerve.

The proper assessment of normal anatomical data directed to formulate important indicators for any pathological changes. Different authors indicated a normal/abnormal threshold (a cutoff value) of the ONSD diameter from 4.8 mm to 5.9 mm with numerous variations between these numbers. [18,19]

The current study reveals a reference values measured in axial MRIs for OND and it was found to be 3.05 ± 0.23 for the right side and 3.05 ± 0.22 for the left side, and the ONSD was 5.05 ± 0.34 and 5.06 ± 0.35 for both right and left sides respectively.

A review of the literature has found the normal optic nerve sheath diameters just behind and 4 mm posterior to the globe are 5.52 ± 1.11 and 5.2 ± 0.9 mm. The optic nerve sheath is widest anteriorly behind the globe and narrowed toward the orbital apex. These dimensions are consistent with the results of a histologic study of the optic nerve.[21]

The mean ONSD in the diabetic group was 5.03 ± 0.53 mm for the right, and 5.08 ± 0.48 for the left showing no difference from that in control group $p = 0.795$ and 0.742 respectively

The study indicated that MR OND measurement in diabetic patients differs from the reference values that have been read from normal in the control group. table(1). There is significant deference between measurement done for the optic nerves between diabetic and control group. $p=0.000$

Axial MRI showed simplicity at measuring ONSD and OND and has been proposed to detect decreasing in measurement of ON in diabetics. On T₂-weighted sequences, water and CSF exhibits a high signal. Fat and grey matter appears as light grey and white matter as dark grey. The perioptic CSF is surrounded by orbital fat. Contrast between CSF and orbital fat was improved because of using the fat suppression technique in our methodology, which increased the image resolution for the ONSD measurement. This was also done in the research method done by Shofty B et al 2012[11]

A number of studies have used imaging techniques to investigate the anatomic changes of the optic nerve. Of the many imaging techniques, MR imaging has been of particular interest because of its ability to provide gross visualization of the optic nerve. Additionally, MR imaging provides higher soft-tissue contrast and free section orientation capabilities However the ON has been technically difficult to be imaged image because of its small size: It is 0.4–0.6 cm in diameter within the orbit.[21] Our results were found to be within the similar range of values .

linear relationship between the duration of diabetic and right optic nerve measurements was found. when the duration of diabetic increased the measurement decreased by -10.16 starting from 37.47 mm $r^2 = 0.094$ and for left optic nerve measurement, when the duration of diabetic increased, the measurement decreased by -16.66 starting from 53.24mm $r^2 = 0.193$.Fig(2,3).The justification taken for those facts is because in diabetic patients the nerve fiber layer is decreased, particularly in the superior segment of the retina, even before the development of clinical presentation. it was mentioned that the nerve fiber layer thickness decreases with the development of diabetic retinopathy and with impairment of metabolic regulation of diabetic.[15].Elevated blood glucose levels cause an elevated retinal glucose level, resulting in a hypoxic –imbalance that may contribute to the ischemia those precedes the development of diabetic retinopathy. [15] This describes the causes of measurements reduction seen in table (1)

New equations were established for the prediction of the OND changes/reduction in known duration of diabetics =

Left (ON) diameter = - 16.07 X duration of diabetes/years +53.24

Right (ON) diameter = -10.16 X duration of diabetes /years +37.47

Frequently the early stages of diabetic retinopathy have no visual symptoms. That is why the American Optometric Association recommends that everyone with diabetes have to do eye examination once a year. Early detection can limit the potential for significant vision loss from diabetic.[26]

MR imaging as measuring the ON and ONSD may facilitate for early prediction and detection of changes of elevated diabetic change in the optic nerve.

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