

## Norms of Optic Nerve Length on MR Imaging for Adults Sudanese

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**Abstract :** The aim of this study is to evaluate the length of the optic nerve (ON) in normal Sudanese using magnetic resonance imaging (MRI). This study was performed in Radiology Department of Royal Care International Hospital - Khartoum, Sudan, during the period of January 2015 up to 2018. One hundred normal subjects were included in this study with range of age (18-80) years old and both genders. All patients underwent to MR imaging for brain for various reasons (such as headaches, blurring vision ...etc) and their results were interpreted as normal by an expert radiologist. Diabetic, hypertension, any eyes problem were excluded. Of the one hundred subjects 45 (45%) were males and 55 (55 %) were females. The mean age of the subjects was 39.46 years. The ON is divided into four parts: intraocular part, intraorbital part, intracanalicular part and intracranial part and have been measured using caliper in (mm). The overall mean length of the right and left optic nerve for all the patients studied was  $46.82 \pm 1.46$  mm. and  $46.82 \pm 1.46$  mm respectively. The minimum was 43.40 mm and maximum was 50.09 mm for the right side and from 43.39 mm to 50 mm in maximum for the left. The mean RT ocular length was  $1.10 \text{ mm} \pm 0.13$ , orbital  $25.88 \text{ mm} \pm 0.78$ , canalicular  $9.26 \text{ mm} \pm 1.07$  and cranial  $10.61 \text{ mm} \pm 0.79$ . LT ocular length was  $1.10 \text{ mm} \pm 0.13$ , orbital  $25.88 \text{ mm} \pm 0.79$ , canalicular  $9.23 \text{ mm} \pm 1.07$ , cranial  $10.60 \text{ mm} \pm 0.79$ . A positive linear relationship between the age with right and left optic nerve length ( $r^2 = 0.159$ ) and ( $r^2 = 0.163$ ) was noticed. The p-value of (t) test is (1.00) that led to accept that there is no deference between measurement length of the optic nerve for the right and left on length. New equations to estimate the right and left ON length for known Sudanese age were established. The study suggested some recommendations and future studies which could be useful in this element.

**Keywords:** - Optic nerve, MRI, T<sub>2</sub> weighted

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### I. INTRODUCTION

The optic nerve (ON) is a white matter tract of the CNS that passes through the optic canal into the orbit. Anatomically, the nerve is divided into orbital and intracanalicular components. The orbital portion consists of the bulbar segment followed by the midorbital segment. [1]

ON is about 50 mm long and is divided into four segments. These are: Intraocular (1 mm), Intraorbital (25 mm), Intracanalicular (9 mm) and Prechiasmatic (16 mm). [2]

Studies have mentioned that the length of the optic nerve varies widely, even between the two eyes of the same person and is 35–55 mm from the eyeball to the chiasma: intraocular part (1 mm), intraorbital part (25 mm), intracanalicular part (4–10 mm) and intracranial part (10 mm) [3,4]

ON is the link between eyes and brain and most frequently, ON abnormalities are associated with brain abnormalities. Increased intracranial pressure (ICP) may lead to several abnormalities on MR imaging, including vertical tortuosity of the orbital ON, and other complex findings. [5]

Tortuosity has a vast specificity value. Brodsky and Vaphiades [5] theorized that the focal pressure exerted by the bulbous portion of the distended perioptic nerve sheaths on the posterior sclera is insufficient to displace the globes anteriorly. Instead, the globe provides resistance to the distal bulbous portion of the ON, which may kink the inflated ON sheath. [5] and this may have an impact on the length, therefore the measurement of the length may be as an indicator for many pathologies

Imaging of the (ON) is technically challenging due to the small size of the structure [4]. Of the many imaging techniques, MR imaging has been of particular interest because of its ability to provide gross visualization of the optic globe, ON, orbits, and optic tract. [6] Additionally, MR imaging provides higher soft-tissue contrast and free section orientation capabilities compared with CT and appears to be more accurate in assessing the ON than sonography [7]. T<sub>2</sub>-weighted FSE sequences with fat-suppression have been found to be optimal for visualizing the ONs and perioptic CSF [7]

A review of the literature has found very little regarding standardized norms of ON length on MR imaging for adults mainly Sudanese at different ages in order to exclude any presence of pathology, ICP and tortuosity . The aims of this study were to establish age-correlated norms for Sudanese ON length and to compare it with other populations .This established values can be used as an auxiliary value in the investigation of suspected ICP as well to provide an anatomic basis for recognizing the crucial special structures and thus aid medical imaging diagnosis of diseases involving the optic pathways.

## II. MATERIALS AND METHODS

This study was performed in Radiology Department of Royal Care International Hospital in Khartoum, Sudan, during the period of January 2015 up to 2018.

### 2.1 MRI Machine:

Equipment used in this study includes: Toshiba system 1.5 Tesla, head coil for head exam, head support pads, ear plugs and PACS System.

### 2.2 Inclusion Criteria:

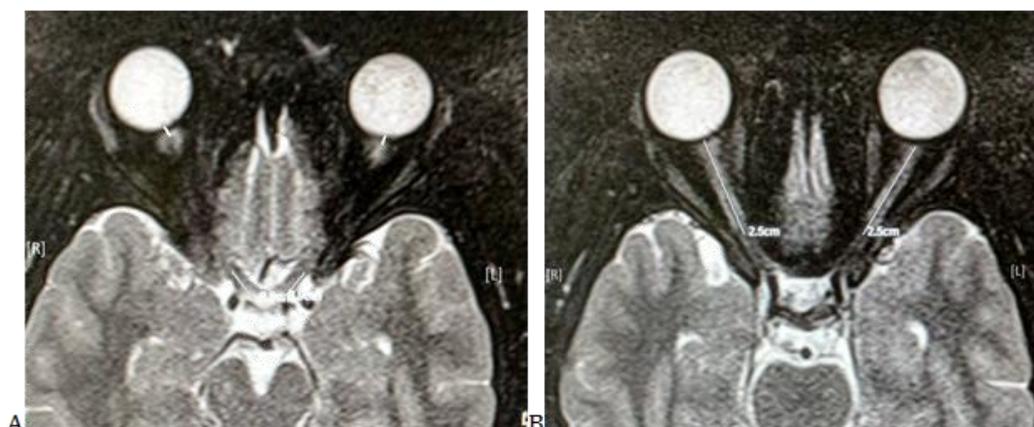
One hundred normal subject were included in this study with range of age (18-80) years old and different gender. All patients underwent to MR imaging for brain for various reasons (such as headaches, blurring vision ...etc). And their results were interpreted as normal by an expert radiologist.

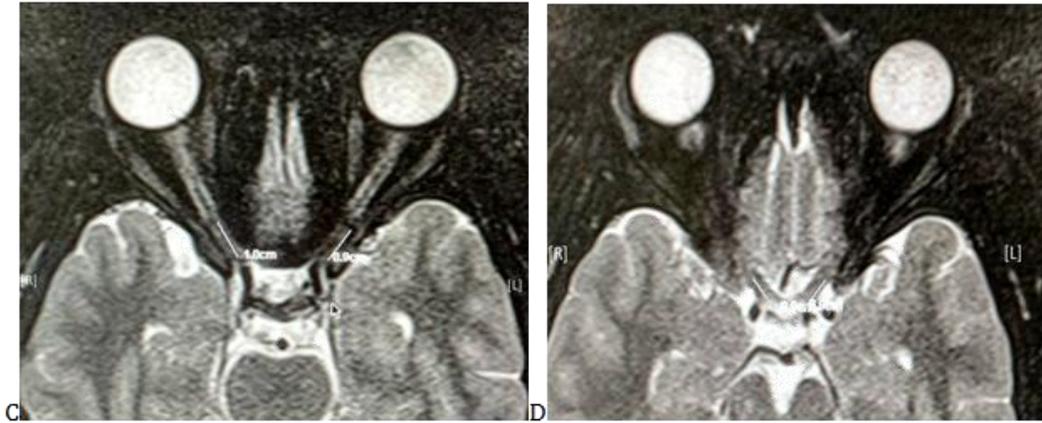
### 2.3 Exclusion Criteria:

Subjects with diabetic and hypertension and those with eyes problems such as Papilledema, idiopathic intracranial hypertension...Etc were excluded. The data were collected and analyzed using Excel program and SPSS.

### 2.4 Technique for Optic Nerve Measurement:

The patients filled out the questionnaire and remove any metal (hearing aids, hair pins, body jewelry, watch, etc). The patients lie 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. This enables the patient to focus and keeps the eyes still, thereby reducing motion artifact. The patient is positioned so that the longitudinal alignment light lies in the midline, and the horizontal alignment light passes through the orbit. Straps and foam pads are used for immobilization. From the PACS system, using the measurement ruler; the optic nerve length was measured. The length of optic nerve was measured at four steps starting passes through sclera, choroid, and appears in eye as optic disc there are intraocular portion, intraorbital part; extends from back of the eyeball to the optic foramina, intracanalicular; as it passes through bony optic canal along with ophthalmic artery, and the area of the intracranial; lies above the cavernous sinus and converges with its fellow to form the chiasm. Axial T2-weighted turbo spin-echo fat-suppressed sequence was used to measure optic nerve pathway. The scan parameters were as follows: repetition time; 3550, echo time105, slice thickness 1.0\*0.6mm \ 3mm, field of view 19.4 \*19.4cm and matrix is 192\*320.The axial image slice that provided the best view of the optic nerve. The retrobulbar area was zoomed to 300×300, and then using an electronic caliper. The optic nerve pathway values obtained from both sides were averaged.





**Fig.1** .Example of our measurement method, axial T2-weighted FSE image demonstrates bilateral presentation of the ON sheath in a 19-year-old female and the patient had no diabetic, or hypertension or any eyes problems A. the area of the ocular part B. the area of orbital part C. area of canalicular part D. area of the intracranial part.

**III. RESULT**

The One hundred subjects were included constituting 45 (45%) were males and 55 (55 %) were females. The mean age of the subjects was 39.46years with a range of 18–80 years. The optic nerve were divided into four parts in the study according to A review of the literature Foram Gala, 2015,[8] and S.S. Hayreh, 2011[9] .

**Table 1: shows patient age, Minimum, Maximum, Mean, Stander deviation data values of measurement of right optic nerve.**

	Age	Ocular	Orbital	Canalicular	Cranial	Optic nerve length
N	100	100	100	100	100	100
Mean	39.46	1.10	25.88	9.26	10.61	46.82
Std. Deviation	15.81	0.13	0.78	1.07	0.79	1.46
Minimum	18.00	1.00	25.00	6.00	9.23	43.40
Maximum	80.00	1.50	30.00	10.98	13.25	50.09

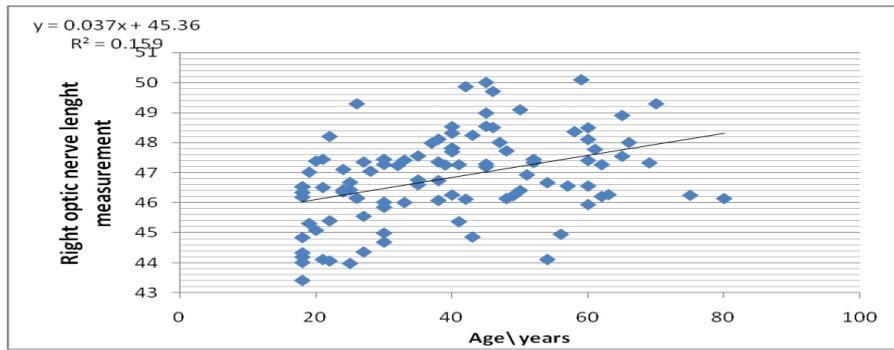
**Table 2: show patient age, Minimum, Maximum, Mean, Stander deviation data values of measurement of left optic nerve.**

	Age	Ocular	Orbital	Canalicular	Cranial	Optic nerve length
N	100	100	100	100	100	100
Mean	39.46	1.10	25.88	9.23	10.60	46.82
Std. Deviation	15.81	0.13	0.79	1.07	.79958	1.46
Minimum	18.00	1.00	25.00	6.00	9.22	43.39
Maximum	80.00	1.50	30.00	10.90	13.20	50.00

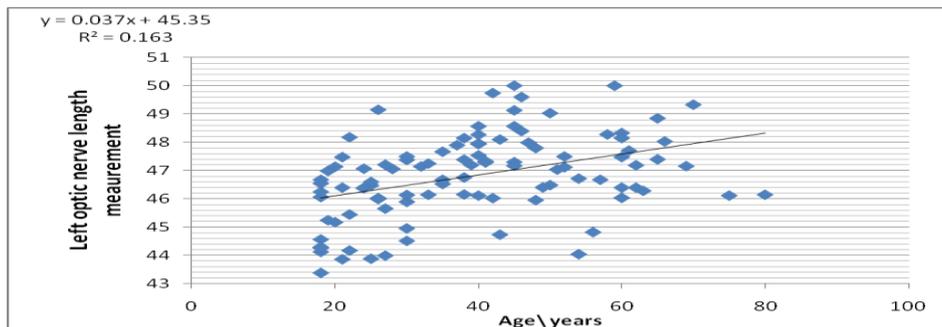
**Table 3: show the comparison between the mean length of the right and left optic nerve measurement Independent Samples Test**

Measurement nerve	normal/optic	N	Mean	Std. Deviation	Std. Error Mean	t	p-value
right and left	right	100	46.8236	1.46	.14634	.000	1.000
	left	100	46.8237	1.45	.14597	.000	1.000

The P- value of (t) test is (1.00) in right, (1.00) in left it's greater than 0.05 that lead to accept there is no deference between measurement length of the optic nerve.



**Fig.2** scatter plot diagrammed shows the linear relationship between the age of the patients and right optic nerve measurement, when the age increased the measurement will be increased by 0.037 starting from 45.35  $r^2 = 0.159$ . { RT ON length=0.037age+45.36}



**Fig.3** scatter plot diagrammed shows the linear relationship between the age of the patients and left optic nerve measurement, when the age increased the measurement will be increased by 0.037 starting from 45.35  $r^2 = 0.163$ . { LT ON length=0.037age+45.35}

#### IV. DISCUSSION AND CONCLUSION

The optic nerve was protected by the adipose body of the orbit[10], for this reason we used T2-weighted FSE sequences with fat-suppression because it have been found to be optimal for visualizing the ONS and perioptic CSF.[11,12,13]

A good understanding of the structure of the ON and topographic localization of the nerve fibers in it from the various parts of the retina is essential for comprehension of various aspects of optic neuropathology. The importance in taking care about the ON is because the perioptic meninges or ONS envelope the length of the ON up to the globe and continued with the intracranial meninges. For this reason, pressure changes in the intracranial space can be transmitted to the optic papilla via the sub arachnoid space(SAS) accompanying the ONS.[14] as well the SAS of the ON divisions are not uniform in architecture: consists of trabeculae, septa and pillars, trabeculae and pillars. [1]This architectural meshwork may affect the pressure within the nerve. However we did not consider the sheath in our evaluation which may consider as limitation. The overall mean length of the right and left optic nerve for all the patients studied was  $46.82\text{mm} \pm 1.46$  and  $46.82\text{mm} \pm 1.46$  respectively. The minimum was 43.40mm and maximum was 50.09mm in the right side and from 43.39mm to 50mm in maximum for the left, this was presented in table [1,2].

A positive linear relationship between the age with right and left optic nerve length ( $r^2=0.159$ ) and ( $r^2=0.163$ ) were noticed. The p- value of (t) test is (1.00) that led to accept that there is no deference between measurement length of the optic nerve for the right and left on length. Studies have mentioned that the length of the optic nerve varies widely, even between the two eyes of the same person [3,4] this was not consistent with our study results .

The current study used the axial MR T<sub>2</sub> weighted images to evaluate the ON length; axial sections were used because they are highly reproducible and are acquired according to a well-defined view. In addition, axial images are routinely used in our department as basic examination and are most likely to be available for the reviewing radiologist; this was also applied in another similar study [15]. Coronal images were not always obtained however coronal image acquisition is needed for optimal visualizing of the true dimensions of the on and perioptic CSF relative to the surrounding sheath.[16]

studies have mentioned that ON is about 50 mm in length [2,7] while another one stated that ON is about 35–55 mm from the eyeball to the chiasma[3,4],the optic nerve length obtained in this study was in the lower range of the values reported in previous studies. A positive linear relation between age and the optic nerve

length was found. New equations to estimate the right and left on length for known Sudanese age were established

$$\{\text{RT ON length (mm)}=0.037 \times \text{age/years}+45.36\},$$

$$\{\text{LT ON length (mm)}=0.037 \times \text{age/years}+45.35\}$$

Due to diversity of ethnicity in Sudan further studies are required to establish local reference of values for the different mores presented in Sudan with large sample size, considering the gender and different imaging planes as the coronal and sagittal planes.

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