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Original Article

Normal Measurements of Optic Nerve Sheath Diameter Using Magnetic Resonance Imaging

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ABSTRACT

Introduction: The optic nerve is a direct continuation of the brain, surrounded by subarachnoid space. Measurement of the Optic Nerve Sheath Diameter (ONSD) provides indirect evidence of intracranial hypertension. Normative data in children in 1st decade is different from that of adults. This study provides age wise diameter of the optic nerve sheath from 0-80 years on T2 weighted MR images in a 1.5 Tesla MR scanner. The data serves as a baseline standard for comparison of ONSD in patients of various age groups. **Objectives**: To establish age and sex wise reference norms for ONSD from 0-80 years. **Materials And Methods:** This was a retrospective cross sectional study of analysis of MR image data set of 200 consecutive MRI studies of the brain, with normal optic nerves. A total of 400 optic nerve sheath diameters were measured (200 patients, both eyes). The study population was divided into 8 age groups of each decade of life from 0 to 80 years. The data was tabulated age and sex wise, for both the eyes and analyzed. **Results**: The mean diameter of the right optic nerve sheath was 4.48 mm with standard deviation of 0.69 (2 SD) and that of the left was 4.54mm with standard deviation of 0.71 (2 SD).Minimum diameter of the right and left optic nerve sheath was 2.98 mm and 2.80 mm respectively in a 14 month old male .Maximum diameter of the right and left optic nerve sheath was 5.5 mm and 5.4 mm respectively in a 16 years and 58 years old female. There was no statistically significant difference between the mean ONSD of the right and left nerves and between males and females. **Conclusion**: This study provides a baseline age wise ONSD and orbital diameter of general population. The maximum ONSD in any age group is never above 5.5 mm. If higher ONSD is found, the patient should be thoroughly investigated for intracranial hypertension.

Key Words: *Optic nerve sheath diameter, normal measurements, MRI*

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INTRODUCTION

The optic nerve is a white matter tract of the Central nervous system, which passes through the optic canal into the orbit. It is surrounded by subarachnoid space and it experiences the same pressure changes as that of the intracranial compartment. The dural sheath of the optic nerve distends with elevation of intracranial pressure and it collapses with intracranial hypotension.

MRI is the modality of choice for evaluation of optic nerve pathway imaging[1]. Head coil is used commonly; howeverwhen surface coil is applied, it improves the signal to noise ratio (SNR) of the globe. Thin coronal and axial T1 and short tau inversion recovery (STIR)/T2 fat-saturated sequences, sagittal T2 fat-saturated sequences are obtained for optic nerve evaluation. A section thickness of 3-4 mm with an interslice gap of about 0-1 mm is preferred. Optic nerve is approximately 50 mm long and is divided into four segments[1].

- **Intraocular (1 mm)** - when it emerges through the scleral opening
- **Intra orbital (25 mm)** - the longest segment and communication between subarachnoid space around the optic nervewith that in suprasellar cistern
- **Intracanalicular (9 mm)** - as it passes through bony optic canal along with ophthalmic artery (OA)
- **Prechiasmatic (16 mm)** - intracranial segment in suprasellar cistern.

It joins the contralateral optic nerve to form optic chiasma, where the nasal fibers from each optic nerve decussate andtemporal fibers do not decussate.

Optic chiasma lies typically about 10 mm above the pituitary gland, separated by the suprasellar cistern. In about 80%of the population, it rests directly above the sella.

However, it may rest above tuberculum sellae in 10% (prefixed chiasm) and aboved orsum sellae in the remaining 10% of the population (postfixed chiasm). The prefixed chiasm has short optic nerves and long optic tracts, whereas the postfixed chiasm has long optic nerves and short optic tracts[2] Pituitary stalk angle is 90° or more in prefixed optic chiasm and acuteangle for normal or postfixed chiasm[3].

From the optic chiasma, optic tracts course posterolaterally along the cerebral peduncles to synapse at lateral geniculate bodies. From the lateral geniculate nuclei, optic radiations fan out as optic radiations and reach the primary visual cortex in the occipital lobes.

PURPOSE OF THE STUDY:

The main objective of this study is to establish age and sex wise reference norms for ONSD from 0-80 years.

MATERIALS AND METHODS:

This was an retrospective observational study done at Dr.PSIMS & RF, Gannavaram using MR image data set of 200 consecutive MRI brain studies performed between January 2018 to June 2018. Institutional ethical committee approval was taken. The patients had undergone MRI scan of the brain in Philips 1.5 Tesla MRI scanner for various conditions.MR images of all age groups from 0 to 100 years without abnormality in the optic pathway were included in the study.

MRI PROTOCOL:

Imaging was performed using 1.5 Tesla, Philips Achieva MRI. The 32 channel head coil was used to acquire the images. Conventional axial T2 weighted turbo spin echo images were used for the analysis. The scanning parameters wereas follows: TR:4600msec, TE: 100 msec, FOV:22-24 cm, matrix size: 512 x 512, slice thickness of 5 mm.

STATISTICAL ANALYSIS: Statistical analysis was done using SSPS software version 2017.

IMAGE ANALYSIS:

The ONSD was measured just behind the optic globe. The retrobulbar area was zoomed and then ONSD was measured in an axis perpendicular to the optic nerve, 3mm behind the globe using an electronic caliper.(Figure 2)

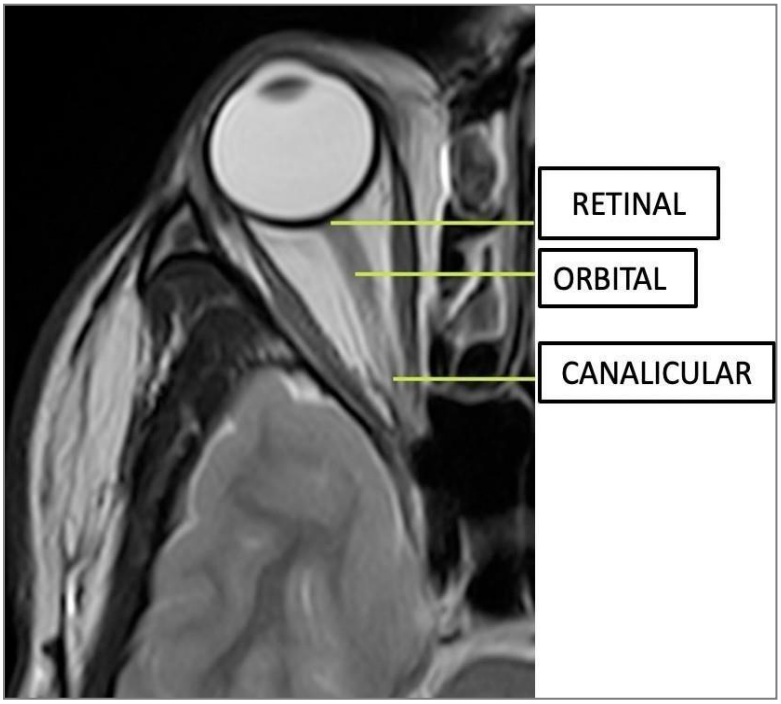


Figure 1 : T2W axial MRI image showing normal optic nerve segments: Retinal, orbital and canalicular.

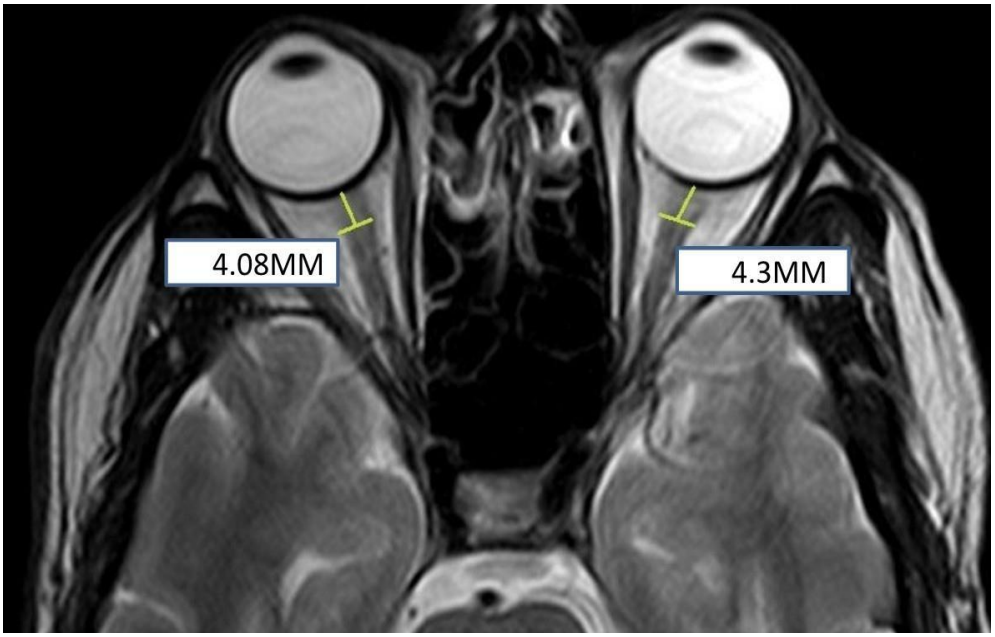


Figure 2: Measurement of optic nerve 5 mm behind the ocular globe at an axisperpendicular to the optic nerve.

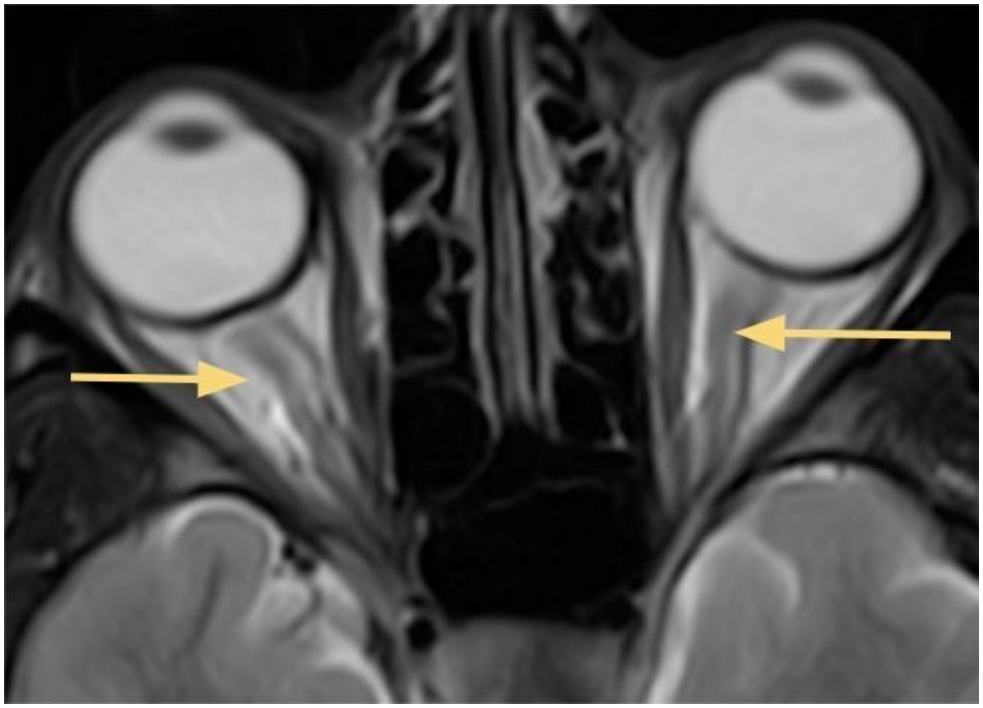


Figure 3 : T2W axial MRI showing dilated and tortuous optic nerve sheath in a cse of bacterial meningitis.

RESULTS:

Out of the 200 patients, 109 were males (54.5%) and 91 were females (45.5%). The mean diameter of the right optic nerve sheath was 4.48 mm with standard deviation of 0.69 (2 SD) and that of the left was 4.54mm with standard deviation of 0.71 (2 SD). Minimum diameter of the right and left optic nerve sheath was 2.98 mm and 2.80 mmrespectively in a 14 month old male. Maximum diameter of the right and left optic nerve sheath was 5.5 mm and 5.4 mmrespectively in a 16 years and 58 years old female. There was no statistically significant difference between the mean ONSD of the right and left nerves. No statistically significant difference was found between males and females.

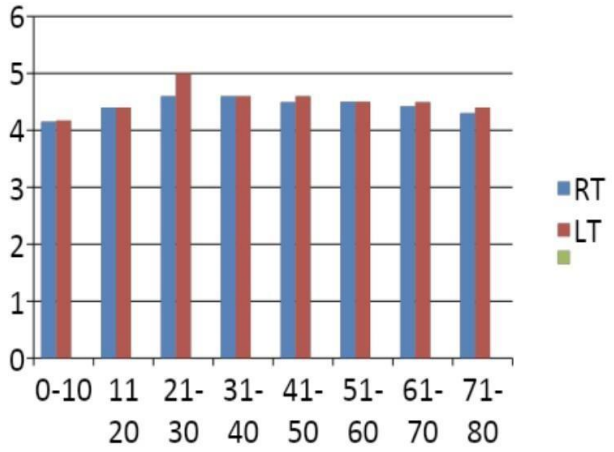
Table 1 : Table showing comparison of right and left optic nerve sheath diameters.

	RIGHT ONSD	LEFT ONSD
NO.OF PATIENTS	200	200
MEAN(mm)	4.48	4.54
STANDARD DEVIATION	0.69	0.71
MAXIMUM(mm)	5.5	5.4
MINIMUM(mm)	2.98	2.8

Table 2 : Table showing relationship between sex and means of ONSD

	MALE	FEMALE	T VALUE	P VALUE
R.ONSD	4.56	4.55	0.736	0.462
L.ONSD	4.36	4.43	1.6	0.134

Table 3 : Table showing mean ONSD in various age groups of this study.



AGE	RT	LT
0-10	4.15	4.17
11 20	4.4	4.4
21-30	4.6	5
31-40	4.6	4.6
41-50	4.49	4.6
51-60	4.5	4.5
61-70	4.42	4.49
71-80	4.3	4.4

DISCUSSION:

Even though MRI of the brain is routinely performed for various conditions, age adjusted normal values of ONSD on a large population are not available. This study provides an age matched normal values of ONSD from 0-80 years as a baseline data for further comparison. It is a known fact that MRI provides better soft tissue resolution than CT and ONSD can be accurately measured using it. Detection of raised ICP in idiopathic intracranial hypertension and malfunctioning of shunts is easier in MRI than CT.

In our study, measurements were performed on 500 subjects aged from 0-100 years using T2 sequence.T2 sequence was chosen as it is routinely performed and the ONsheath as well as the nerve are well visualized in it. We have stratified the measurements according to each decade of life and this is the study with such age wise distribution of optic nerve measurements in general population.

This study reports normal measurements of the optic nerve sheath diameter in patients using high-resolution MRI. There were no statistically significant differences between males and females for all the acquired measurements of the

optic nerve sheath. This finding is consistent with the previous literature and is expected because there are no known structural or physiological differences of the anterior visual pathway structures between sexes. These observations are consistent with findings by Dolman et al[4] and Beneventoet al.[5].

Traditionally, measurements are obtained manually by using electronic calipers. With the advent of artificial intelligence (AI) and its growing clinical applications, newer techniques of obtaining anterior visual pathway structures are being investigated with good outcomes.

In a study of 47 patients, Lagrèze WA et al[6], measured the optic nerve diameter at mm, 10 mm and 15 mm behind the globe in a 3T MR system and observed better correlation between the optic nerve diameter and the Retinal Nerve Fiber Layer (RNFL), adjacent to the orbital apex than adjacent to the globe. The measurements in our study were taken at a distance of 5 mm (0 to 80 years) behind the globe.

LIMITATIONS:

Thin section 3D CISS images of the optic nerves provide higher resolution than T2weighted images of the brain. As this sequence is not routinely performed, and as the intention of the study was to detect the variations in ONSD on routinebrain MR images, the study was conducted on T2 axial images only.

CONCLUSION:

This study provides a baseline age wise ONSD of Indian population. In general, ONSD of general population is always less than 5.5 mm. Any subjects with values above this should be thoroughly investigated for intracranial hypertension.

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