Journal of Experimental and Clinical Medicine
https://dergipark.org.tr/omujecm

Research Article

J Exp Clin Med
2021; 38(4): 545-549
doi: 10.52142/omujecm.38.4.27

Determination of normal values of optic nerve sheath diameter in Turkish adult population using magnetic resonance imaging

Serkan Emre EROĞLU [1], Hayrullah YÖNAK [2], Mehmet Muzaffer İSLAM [1]*, Gülbanu GÜNER [3], Gökhan AKSEL [1], Zakir SAKCI [1]

[1]Emergency Medicine Department, Umraniye Training and Research Hospital, University of Health Sciences, Istanbul, Turkey
[2]Emergency Medicine Department, Şehit Prof. Dr. İlhan Varank Training and Research Hospital, University of Health Sciences, Istanbul, Turkey
[3]Radiology Department, Umraniye Training and Research Hospital, University of Health Sciences, Istanbul, Turkey

Received: 04.04.2021 • **Accepted/Published Online:** 01.05.2021 • **Final Version:** 30.08.2021

Abstract

The measurement of optic nerve sheath diameter (ONSD) is a reliable tool for the estimation of increased intracranial pressure (ICP). However, it is known that racial changes can occur in human anatomy. In the present study we aimed to determine the normal values of ONSD in Turkish adult population. This retrospective study involved the collection of data between June 1, 2015, and May 31, 2019, and was conducted on 291 adults known to have no increased cranial/intraocular pressure. The ONSD was measured at 3 mm posterior to the globe on MR images. 291 subjects were enrolled, 63.6% of whom were female. The total median ONSD was 4.40mm (4.20- 4.70). The median ONSD of the male participants was 4.50mm (4.25-4.75), of the female participants was 4.35mm (4.15-4.50) and the difference was statistically significant ($p = 0.001$). According to statistical analysis, it was found that only the presence of chronic renal failure altered the median of ONSD among the comorbid diseases ($p = 0.042$). Monitoring and treating increased ICP is crucial. Thanks to an ONSD with a known normal value, recognition and emergency management of this pathology would be easier. We think our study is noteworthy because it is the first study investigating the normal ONSD value in Turkish adult population.

Keywords: MRI, normal value, optic nerve sheath diameter, Turkish adult population

1. Introduction

The optic nerve, also called the second cranial nerve, transfers visual information from the retina to the vision centers of the brain via sensory nerve impulses. It is surrounded by cerebrospinal fluid, and its sheath is anatomically continuous with the duramater (1). This anatomical feature is so important. Such that, when the presence of increased intracerebral pressure (ICP), increased pressure will be transmitted from the subarachnoid space to the optic nerve and the surrounding nerve sheath. So, the detection of an increase in optic nerve sheath diameter (ONSD) due to this pressure may indicate an increase in the ICP (2, 3).

Nowadays, the mean upper limit for ONSD is accepted as 5 mm at most in adults (4). However, it may be wrong to assume that there is a universal ONSD value for all people around the world because it is known that there are variations in orbital anatomy with age, sex, and race.

A study conducted by Varma et al. was demonstrated that the mean optic disc area was 12% larger in Blacks compared to Whites (5). Wang et al. found significant differences in the lens position and relative lens position among various ethnic groups such as White, Asian, Hispanic, and Black populations (6). Samarawickrama et al. reported that after adjusting for age, gender, axial length, birth weight and optic-disc area, East Asian children had 30–43% larger mean vertical cup diameters compared to European Caucasians (7). The average cup/disc ratio in blacks (0.35) was significantly greater ($p < 0.0001$) than that in whites (0.24) for both right and left eyes (8). Moreover, there are also many other studies which have demonstrated that the ethnic background of the patients affects the optic nerve and eye anatomy (9-13).

We thought that it would not be surprising that a similar situation is also valid for ONSD. Based on this assumption, the aim of this study was to establish a reference scale of optic nerve sheath diameter in Turkish population using Magnetic Resonance Imaging (MRI).

2. Materials and methods

This retrospective study was approved by Ümraniye Training and Research Hospital local ethics committee and was retrospectively conducted on 291 patients who visited our hospital between June 1, 2015, and May 31, 2019. The data of the patients' descriptive characteristics and MR images included in our study were taken out from our hospital's

* Correspondence: mehmetislam1988@gmail.com

medical records. Since the study was retrospective, the informed consent was not requested from the patients. This study conformed to the principles in the declaration of Helsinki.

The patients over the age of 18 who were requested orbital MRI for various reasons and then reported as normal MRI results were included to our study. The patients with any ophthalmologic or neurological disorders, patients using medications and/or eye examination findings (trauma, tumor, infection, papillary edema, glaucoma etc.) that affect cerebrospinal fluid pressure, and those with poor imaging quality due to movement or metallic artifacts were excluded from the study. The included eye examination findings were the findings admitted not needed rapid emergent intervention such as dry eye, retinopathy with no papilledema and hemorrhage, stye, hyphemia, scleritis etc.

Because of its greater accuracy, reliability, objectivity, and lower observer-dependent nature, we planned to use MRI for ONSDm in our study. MRI scans were performed on an Optima™ MR450W (1.5T, General Electric Company, United States) machine according to routine imaging protocols. The measurements were retrospectively analyzed with computer-assisted segmentation and performed manually by two neuroradiologists.

ONSD measurements were taken in the supine position. Axial T2-weighted MR images were used to measure the ONSD of each eye. ONSD is defined as the distance between the outer edges of the thick sheath layers covering the optic nerve. The measurement was performed from the image plane at the posterior aspect of the globe and at 3 mm behind the globe in an axis perpendicular to the optic nerve.

Statistical analysis was performed using the SPSS (IBM Corp. Released 2019. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.). The normality of the distribution of continuous and discrete variables was tested using histograms, Q-Q plots, and the Shapiro Wilk test. Categorical data were expressed as number and frequency. Continuous variables with normal distribution were described with mean (SD). The quantitative data with non-normal distribution were expressed by median and interquartile range (IQR). Mann Whitney-U and Kruskal-Wallis tests were used to compare quantitative data with non-normal distributions. P value of less than 0.05 was admitted statistically significant.

The primary outcome is a reference scale of optic nerve sheath in Turkish population. Secondary outcomes are changes in the measurement of ONSD (ONSDm) among with demographic and clinical characteristics of the patients.

3. Results

291 patients who met the inclusion criteria out of 920 patients performed orbital MRI during the study period was included, and their ONSD was measured. A patient flow chart is shown in Fig. 1.

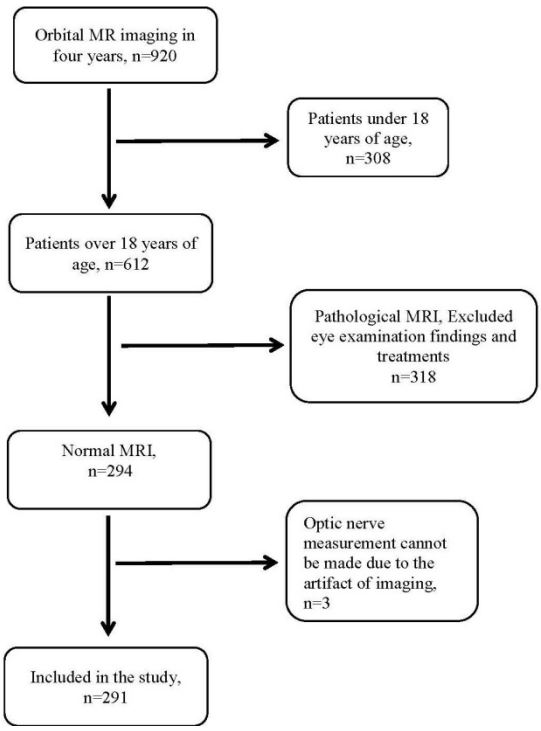

Fig.1. Patient flow chart

Of these 291 patients, 185 (63.6%) were women. The median age of the patients was 41 (30-52) and their descriptive characteristics are summarized in Table 1.

Table 1. Descriptive characteristics of the patients

Age *[Median (%25 - %75 IQR)]*	41 (30-52)
Gender (Female) *[N (%)]*	185 (63.6)
Comorbidities *[N (%)]*	
Diabetes Mellitus	34 (11.7)
Hypertension	48 (16.5)
Coronary Artery Disease	12 (4.1)
Hyperlipidemia	24 (8.2)
Chronic renal failure	3 (1)
Malignancy	3 (1)
Ischemic Stroke	1 (0.3)
Chronic obstructive pulmonary disease	21 (7.2)
Geographical region where the patient ID is registered *[N (%)]*	
Aegean	6 (2.1)
Marmara	55 (18.9)
Black Sea	115 (39.5)
Mediterranean	4 (1.4)
Central Anatolia	41 (14.1)
Southeastern Anatolia	7 (2.4)
Eastern Anatolia	63 (21.6)

The median of the right optic nerve sheath diameter (ONSD) of the patients was 4.40mm (4.20 - 4.70), the median of the left ONSD was 4.30mm (4.10 - 4.60), and the median of the total (right and left) ONSD was 4.40mm (4.20 - 4.70). When the difference between right and left ONSD was examined, no statistically significant difference was found (Mann Whitney-U test, $p = 0.319$). Primary outcome measures are summarized in Table 2.

Table 2. Primary outcome measures

	Median (%25 - %75 IQR)	p
Right ONSD (mm)	4.40 (4.20 - 4.70)	0.319
Left ONSD (mm)	4.30 (4.10 - 4.60)	
Total ONSD (mm)	4.40 (4.20 - 4.70)	

ONSD: Optical nerve sheath diameter; IQR: Interquartile range; mm: millimeter

When the age of the patients included in the study was divided into decades starting from the age range of 18-29, there was no statistically significant difference between decades and median ONSD. (Kruskal Wallis test, p = 0.489).

The median ONSD value of male patients was 4.50mm (4.25-4.75). It was also calculated as 4.35mm (4.15-4.50) for female patients, and this difference was statistically significant (Mann Whitney-U test, p = 0.001).

While the median ONSD value of patients without chronic renal failure (CRF) was 4.40mm (4.20-4.60), the median ONSD value of patients with CRF was 4.75mm (4.65-5.00). This result was found to be statistically significant (Mann Whitney-U test, p = 0.042). When the medians of ONSD of the patients were compared according to diabetes mellitus, hypertension, coronary artery disease, hyperlipidemia, malignancy and COPD groups, no statistically significant difference was found (Mann Whitney-U test, respectively p = 0.963, p = 0.739, p = 0.139, p = 0.881, p = 0.722, p = 0.658).

When the relationship between the ONSD and the geographical regions of the patients where they were registered was examined with the Kruskal Wallis test, it was found as p = 0.02. But no statistically significant difference was found in the comparisons between the groups (Bonferroni correction was applied, and significance threshold was accepted as p < 0.00238 after Bonferroni correction).

During our analysis, the eye examination findings of the patients included in the study were dichotomized as "normal examination finding" and "pathological examination finding", no statistically significant difference was found between the mean ONSD (Mann Whitney-U test, p = 0.058). Secondary outcome measures are summarized in Table 3.

Table 3. Secondary outcome measures

	ONSD (mm) [Median (%25 - %75 IQR)]	p	Statistical method used
Age (Categorical)	NA	0.489	Kruskal Wallis
Gender		**0.001**	**Mann Whitney-U**
Male	4.50 (4.25 - 4.75)		
Female	4.35 (4.15 - 4.50)		
Presence of comorbidity		0.844	Mann Whitney-U
Present	4.38 (4.20 - 4.60)		
Absent	4.40 (4.18 - 4.60)		
Geographical region where the patient ID is registered	NA	0.02*	Kruskal Wallis
Eye Examination Findings (Dichotomous)		0.058	Mann Whitney-U
Normal Examination	4.40 (4.20 - 4,60)		
Pathological Examination (mean +- SD)	4.30 (0.29)		

*Although p = 0.02, no statistically significant difference was found in the comparisons between groups (Bonferroni correction was applied). mm: millimeter, ONSD; optical nerve sheath diameter, SD; standard deviation

4. Discussion

Many invasive and noninvasive methods can be applied to monitor the ICP. While lumbar puncture one of the invasive methods is not reproducible, intraparenchymal probe and intraventricular catheterizations which are the gold standard in diagnosis cannot be applied under all conditions. Therefore, non-invasive procedures such as tympanic membrane replacement, CT, MRI, fundoscopy, transcranial doppler USG and USG-mediated optic nerve sheath diameter measurement (ONSDm) are used more (14, 15).

In today's practice, USG-mediated ONSDm has become more preferred compared to other non-invasive methods due to its bedside applicability, reproducibility, and easy accessibility to show pressure increase (16-18). And during the uses of this method, the accepted upper limit of normal ONSD values are < 5.0 mm for adults (>15 years of age), 4.5 mm for children and 4.0 mm for infants (19). Despite this accepted value, in studies conducted, this diameter was measured as 4.41 mm (4.25-4.75) in Bangladeshi and 5.1 mm (4.7 - 5.4) in Chinese (4, 20). In another study, where the average ONSD of both eyes was not given; The median right ONSD was 4.11 mm (3.36-4.86) and the median left ONSD was 4.35 mm (3.77-5.10) in Nigerian adult population.21 In our study, the median of the total (right and left) ONSD was found to be 4.40 mm (4.20 - 4.70). The different ONSD results obtained in all these studies strengthen the view that this diameter can vary between ethnic origins.

Our study is the first study that examined ONSD, and

demographic data associated with it in a population living in Turkey, according to our knowledge. In addition to this, the results of some studies performed in Turkey can allow the comparison of our ONSD findings, by using their control groups' ONSD values. In a study using CT that have 61 patients in its control group consisting of the patients with normal CT findings and discharged, the median ONSD mean of both eyes was reported to be 5.76 mm (IQR: 0.96).22 In another Turkish study using CT, this diameter was determined as 4.9. 23 Although they are made in Turkey, the racial characteristics of patients included to the study were not specified in both ones. Additionally, the results of our study are more reliable because of it is an MRI study and also it was performed with more patients.

In our study, the effects of comorbid diseases and the sex on ONSDm were also investigated. Differently from previous studies, a statistically significant difference in ONSD was found between genders in our study (21, 24). In addition, presence or absence of comorbid diseases included in the study did not change ONSDm statistically significantly except for CRF. However, only three of the patients included in the study were CRF patients. We think that studies with larger sample size are needed to make a more accurate interpretation. In addition to this, it should be kept in mind that the population we investigated did not include ICP and its complications. In the case of developing the ICP and its complication, we can see that the ONSD of patients with comorbid disease is affected more than those without comorbid disease.

There are some limitations to our study. In terms of representing the Turkish population, our study has been carried out with a relatively small sample size and a predominantly local population. However, one of the important factors limiting the large sample size is the preference of MR-mediated ONSDm in our study. Although the MR scan has low interobserver variability and greater accuracy, it is also difficult for ONSD associated studies to involve completely healthy volunteers and to use MRI to reach large sample sizes. Moreover, the funding of the study and allowing dedicated MR devices to be used for the study is not easy too. For these reasons, it was included the patients who applied to the hospital with any complaint required MRI examination and did not have ICP findings in this study. Despite the limitation about its sample size, this study gives the first insights into normal optic nerve sheath diameters in Turkish population. In addition to this, considering that our study covers a period of nearly 4 years, the sample size can be increased with multi-center studies using a similar method.

To identify increased ICP is very important for preventing possible herniation and death. ONSD has been proven as a parameter for measuring ICP indirectly. As a result, ONSD of 4.40 mm is the normal value in Turkish adult population according to our study. Despite its limitations, the results of our study are important for the management of these patients. Moreover, we think that the results we obtained will provide an idea for further studies in which pathological values will be investigated.

Conflict of interest

None to declare.

Acknowledgments

This retrospective study was approved by Umraniye Training and Research Hospital local ethics committee.

References

1. Newman WD, Hollman AS, Dutton GN, Carachi R. Measurement of optic nerve sheath diameter by ultrasound: a means of detecting acute raised intracranial pressure in hydrocephalus. Br J Ophthalmol. 2002; 86: 1109–13. doi: 10.1136/bjo.86.10.1109.

2. Dubourg J, Messerer M, Karakitsos D, Rajajee V, Antonsen E, Javouhey E, et al. Individual patient data systematic review and meta-analysis of optic nerve sheath diameter ultrasonography for detecting raised intracranial pressure: protocol of the ONSD research group. Syst Rev. 2013; 2: 62. doi: 10.1186/2046-4053-2-62. PMID: 23919384; PMCID: PMC3751128.

3. Fontanel L, Pensiero S, Ronfani L, Rosolen V, Barbi E. Optic Nerve Sheath Diameter Ultrasound: Optic Nerve Growth Curve and Its Application to Detect Intracranial Hypertension in Children. Am J Ophthalmol. 2019; 208: 421-8. doi: 10.1016/j.ajo.2019.07.014. Epub 2019 Aug 1. PMID: 31377281.

4. Maude RR, Hossain MA, Hassan MU, Osbourne S, Sayeed KL, Karim MR, et al. Transorbital sonographic evaluation of normal optic nerve sheath diameter in healthy volunteers in Bangladesh. PLoS One. 2013; 8(12): e81013. doi: 10.1371/journal.pone.0081013. Erratum in: PLoS One. 2014; 9(1). doi:10.1371/annotation/4e2f88bd-e836-4e0c-a3e0-f6062331702b. PMID: 24312515; PMCID: PMC3846670.

5. Varma R, Tielsch JM, Quigley HA, Hilton SC, Katz J, Spaeth GL, Sommer A. Race, age, gender, and refractive error-related differences in the normal optic disc. Arch Ophthalmol. 1994; 112(8): 1068-76. doi: 10.1001/archopht.1994.01090200074026.

6. Wang D, Amoozgar B, Porco T, Wang Z, Lin SC. Ethnic differences in lens parameters measured by ocular biometry in a cataract surgery population. PLoS ONE. 2017; 12(6): e0179836. doi: 10.1371/journal.pone.0179836.

7. Samarawickrama C, Wang JJ, Huynh SC, Pai A, Burlutsky G, Rose KA, et al. Ethnic differences in optic nerve head and retinal nerve fibre layer thickness parameters in children. Br J Ophthalmol. 2010; 94: 871-876. doi: 10.1136/bjo.2009.158279

8. Roy Beck W, Messner DK, Musch DC, Martonyi CL, Lichter PR. Is There a Racial Difference in Physiologic Cup Size? 1985; 92(7): 873-6. doi: 10.1016/S0161-6420(85)33942-8.

9. Fansi AAK, Papamatheakis DG, Harasymowycz PJ. Racial variability of glaucoma risk factors between African Caribbeans and Caucasians in a Canadian urban screening population. Can J Ophthalmol. 2009; 44(5):576-581. doi: 10.3129/i09-130.

10. Zangwill LM, Weinreb RN, Berry CC, Smith AR, Dirkes KA, Coleman AL, et al. Confocal Scanning Laser Ophthalmoscopy Ancillary Study to the Ocular Hypertension Treatment Study. Racial differences in optic disc topography: baseline results from the confocal scanning laser ophthalmoscopy ancillary study to the ocular hypertension treatment study. Arch Ophthalmol. 2004; 122(1): 22-28. doi: 10.1001/archopht.122.1.22.

11. Girkin CA, McGwin G Jr, McNeal SF, DeLeon-Ortega J. Racial

differences in the association between optic disc topography and early glaucoma. Invest Ophthalmol Vis Sci. 2003 Aug;44(8):3382-3387. doi: 10.1167/iovs.02-0792. PMID: 12882785.

12. El-Dairi M, Holgado S, Asrani S, Freedman SF. Optical coherence tomography (OCT) measurements in black and white children with large cup-to-disc ratios. Exp Eye Res. 2011; 93(3): 299-307. doi: 10.1016/j.exer.2011.05.004.

13. Girkin CA, McGwin G Jr, Sinai MJ, Sekhar GC, Fingeret M, Wollstein G, et al. Variation in optic nerve and macular structure with age and race with spectral-domain optical coherence tomography. Ophthalmology. 2011; 118(12): 2403-2408. doi: 10.1016/j.ophtha.2011.06.013. Epub 2011 Sep 9. PMID: 21907415.

14. Wang LJ, Yao Y, Feng LS, Wang YZ, Zheng NN, Feng JC, et al. Noninvasive and quantitative intracranial pressure estimation using ultrasonographic measurement of optic nerve sheath diameter. Sci Rep. 2017; 7: 42063. doi:10.1038/srep42063.

15. Raboel PH, Bartek J Jr, Andresen M, Bellander BM, Romner B. Intracranial Pressure Monitoring: Invasive versus Non-Invasive Methods-A Review. Crit Care Res Pract. 2012; 2012:950393. doi: 10.1155/2012/950393.

16. Rajajee V, Vanaman M, Fletcher JJ, Jacobs TL. Optic nerve ultrasound for the detection of raised intracranial pressure. Neurocrit Care. 2011; 15(3): 506-515. doi: 10.1007/s12028-011-9606-8.

17. Park JS, Cho Y, You Y, Min JH, Jeong W, Ahn HJ, et al. Optimal timing to measure optic nerve sheath diameter as a prognostic predictor in post-cardiac arrest patients treated with targeted temperature management. Resuscitation. 2019; 143: 173-179. doi: 10.1016/j.resuscitation.2019.07.004.

18. Patterson DF, Ho ML, Leavitt JA, Smischney NJ, Hocker SE, Wijdicks EF, et al. Comparison of Ocular Ultrasonography and Magnetic Resonance Imaging for Detection of Increased Intracranial Pressure. Front Neurol. 2018; 9: 278. doi: 10.3389/fneur.2018.00278.

19. Lin JJ, Chen AE, Lin EE, Hsia SH, Chiang MC, Lin KL. Point-of-care ultrasound of optic nerve sheath diameter to detect intracranial pressure in neurocritically ill children - A narrative review. Biomed J. 2020; 43(3): 231-9. doi:10.1016/j.bj.2020.04.006.

20. Chen H, Ding GS, Zhao YC, Yu RG, Zhou JX. Ultrasound measurement of optic nerve diameter and optic nerve sheath diameter in healthy Chinese adults. BMC Neurol. 2015; 15: 106. doi: 10.1186/s12883-015-0361-x. PMID: 26148482; PMCID: PMC4493801.

21. Anas I. Transorbital sonographic measurement of normal optic sheath nerve diameter in Nigerian adult population. Malays J Med Sci. 2014; 21(5): 24-9.

22. Yesilaras M, Kilic TY, Yesilaras S, Atilla OD, Öncel D, Çamlar M. The diagnostic and prognostic value of the optic nerve sheath diameter on CT for diagnosis spontaneous subarachnoid hemorrhage. Am J Emerg Med. 2017; 35(10): 1408-13. doi: 10.1016/j.ajem.2017.04.022. Epub 2017 Apr 14. PMID: 28431869.

23. Gökcen E, Caltekin İ, Savrun A, Korkmaz H, Savrun ŞT, Yıldırım G. Am J Emerg Med. 2017; 35(11): 1607-11. doi: 10.1016/j.ajem.2017.04.073. Epub 2017 Apr 30. PMID: 28473274.

24. Yapicioglu H, Aslan N, Sertdemir Y, Yildizdas D, Gulasi S, et al. Determination of normal values of optic nerve sheath diameter in newborns with bedside ultrasonography. Early Hum Dev. 2020; 145: 104986. doi: 10.1016/j.earlhumdev.2020.104986. Epub 2020 Apr 23. PMID: 32335478.