© October 2025 | IJIRT | Volume 12 Issue 5 | ISSN: 2349-6002

Assessment of Optic Nerve and Extraocular Muscle Morphology by Using 1.5 Tesla Magnetic Resonance Imaging

Akhalakh Ahamad[1], Dr Ashish Kumar Shukla[2], Abhishek Kaushik[3], Anjali Jain[4], Arif Hussain Malla[5]
[1,2,3,4,5]*Santosh deemed to be university*

***Abstract*—Background: The optic nerve and extraocular muscles (EOMs) are fundamental components of the human visual system. Any variation in their morphology may lead to significant ophthalmic and neurological consequences. Magnetic Resonance Imaging (MRI) has emerged as the most reliable non-invasive imaging modality for assessing orbital structures due to its superior soft tissue contrast and multiplanar capability. This study aimed to evaluate the morphology of the optic nerve and EOMs using 1.5 Tesla MRI and to establish normative data among healthy adults in the Indian population. Methods: A retrospective cross-sectional study was carried out at Santosh Hospital, Ghaziabad, involving 74 healthy subjects (37 males, 37 females) aged between 20 and 70 years. MRI scans were acquired using a 1.5 Tesla system with standard head coil. Axial and coronal T1- and T2-weighted sequences were analyzed for optic nerve and EOM dimensions. Measurements were made using DICOM viewing software. Statistical analyses included t-tests, ANOVA, and Pearson correlations to evaluate gender and laterality differences. Results: The mean optic nerve diameter was 2.45 ± 0.56 mm on the right and 2.36 ± 0.56 mm on the left. The mean widths of the lateral rectus and medial rectus muscles were 1.14 ± 0.48 mm and 1.27 ± 0.48 mm respectively on the right side. Males showed slightly higher mean values than females, with significant differences noted for the right optic nerve ($p < 0.05$). A strong correlation was observed between the right and left optic nerve diameters ($r = 0.857$, $p < 0.01$) and between corresponding EOMs ($r > 0.68$, $p < 0.01$). Conclusion: MRI provides accurate morphometric data for optic nerve and EOM evaluation. These normative findings are essential for diagnosing orbital and neuro-ophthalmic conditions. Further studies using advanced MRI techniques such as diffusion tensor imaging and high-field systems are recommended to refine diagnostic accuracy and detect microstructural alterations.**

***Index Terms*—Optic nerve, Extraocular muscles, MRI, Morphology, 1.5 Tesla, Orbital imaging**

I. INTRODUCTION

The human eye functions as a complex optical system where the optic nerve and extraocular muscles (EOMs) play crucial roles. The optic nerve is composed of approximately 1.2 million nerve fibers that transmit visual signals from the retina to the brain. It is surrounded by the meninges and cerebrospinal fluid (CSF) space, making it sensitive to intracranial and intraorbital changes. The six extraocular muscles superior, inferior, medial, and lateral rectus, along with superior and inferior oblique facilitate coordinated eye movements. Precise evaluation of these structures is vital in diagnosing disorders such as optic neuritis, glaucoma, thyroid eye disease, and compressive neuropathies. MRI has become the imaging modality of choice because of its exceptional soft-tissue contrast, lack of radiation exposure, and capability to delineate the optic nerve and EOMs in multiple planes. Several international studies have established normative data; however, anatomical variations across populations necessitate region specific reference values. This study aims to assess optic nerve and EOM morphology in healthy Indian adults using 1.5 Tesla MRI to create a reliable baseline for clinical interpretation.

II. MATERIALS AND METHODS

Study Design: Retrospective cross-sectional study. Study Setting: Department of Radiodiagnosis, Santosh Hospital, Ghaziabad. Sample: 74 healthy individuals (37 males, 37 females), aged 20–70 years. Inclusion Criteria: Participants with normal ocular history, no prior eye surgery, and no neurological or systemic diseases. Exclusion Criteria: Patients with glaucoma, optic neuropathy, thyroid eye disease, or trauma affecting the orbit. MRI Protocol: MRI scans were performed on a 1.5 Tesla (UMR580) scanner using a dedicated head coil. Sequences included axial and coronal T1-weighted (TR/TE = 600/15 ms), T2-weighted (TR/TE = 4000/100 ms), and FLAIR sequences. Slice thickness was 3 mm with 0.3 mm interslice gap. Imaging was performed with the patient in supine position and eyes in neutral gaze. Images were analyzed on RadiAnt DICOM Viewer for linear measurement of optic nerve diameters and EOM widths at standardized anatomical landmarks. Statistical Analysis: Data were entered into SPSS v21. Descriptive statistics (mean ± SD) were used for continuous variables. Independent t-tests compared gender differences, paired t-tests compared right and left measurements, and Pearson's correlation determined bilateral relationships. Statistical significance was set at $p < 0.05$.

III. RESULTS

The study included 74 subjects equally divided by gender. The mean age was 42.85 ± 16.35 years. Optic nerve diameter was slightly greater in males (2.59 ± 0.52 mm) than females (2.32 ± 0.58 mm), particularly on the right side ($p = 0.04$). No significant side differences were observed for EOM widths. The lateral rectus averaged 1.14 ± 0.48 mm and the medial rectus 1.27 ± 0.48 mm on the right side, both showing strong positive bilateral correlations. A strong correlation ($r = 0.857$, $p < 0.01$) was found between right and left optic nerve diameters, indicating near-perfect symmetry. EOMs also showed consistent symmetry with correlation coefficients above 0.68 ($p < 0.01$). No significant association was found between age and optic nerve or muscle thickness. These results confirm consistent morphological dimensions in normal individuals and suggest gender-based anatomical variations.

IV. DISCUSSION

MRI-based evaluation of the optic nerve and EOMs is an invaluable diagnostic approach for both clinical and research purposes. The findings of the present study correspond with several international studies, confirming that optic nerve and muscle dimensions remain bilaterally symmetric in normal populations. Ominde et al. (2024) and Mncube et al. (2019) reported average optic nerve diameters of 2.4–2.6 mm, aligning closely with our results. The slightly larger measurements in males may be attributed to general craniofacial size differences. Valentine et al. (2020) and Hazarika et al. (2021) similarly observed minor gender-based variations. The absence of significant lateral asymmetry is consistent with previous reports (Clark et al., 2020; Kim et al., 2019). This anatomical symmetry reinforces MRI's reproducibility for both clinical follow-up and research.

In pathologies such as optic neuritis, thyroid-associated orbitopathy, or compressive lesions, even small deviations from normative dimensions are diagnostically significant. Our findings provide clinicians with reference benchmarks for evaluating optic nerve swelling or muscle enlargement. Future studies incorporating functional MRI and diffusion tensor imaging may enable microstructural and fiber-level analysis.

V. CONCLUSION

This study successfully established normative MRI measurements for optic nerve and extraocular muscle morphology in healthy Indian adults. Findings confirmed bilateral symmetry and minor gender variations, highlighting the utility of MRI in establishing reference standards. These data will aid radiologists and ophthalmologists in differentiating normal anatomy from early pathological changes in orbital and neuro-ophthalmic diseases. Further research with larger sample sizes and advanced imaging modalities is recommended to validate and expand upon these results.

REFERENCES

[1] Ominde BS et al. Assessment of normal optic nerve diameter using MRI. Niger J Clin Pract. 2024.

[2] Qureshi A et al. Deep learning segmentation of extraocular muscles from MRI. Radiol Artif Intell. 2023.

[3] Song C et al. Extraocular muscle volume index in optic neuritis. Eur Radiol. 2023.

[4] Kim C et al. MRI of the visual pathways in abducens palsy. AJNR Am J Neuroradiol. 2023.

[5] Zou M et al. Multiparametric MRI evaluation of dysthyroid optic neuropathy. J Magn Reson Imaging. 2021.
[6] Hazarika K et al. Orbital measurements in pediatric population using MRI. Indian J Radiol Imaging. 2021.
[7] Kawai M et al. Analysis of extraocular muscle alignment via MRI. Invest Ophthalmol Vis Sci. 2021.
[8] Ikamaise VC et al. MRI-based nomogram for optic nerve and EOMs. Niger J Clin Pract. 2020.
[9] Clark RA et al. Impact of axial length on extraocular muscle anatomy. Invest Ophthalmol Vis Sci. 2020.
[10] Franceschiello B et al. 3D MRI of freely moving human eye. Magn Reson Med. 2020.
[11] Mncube SS et al. Standard measurements of optic nerve and chiasm in adults. S Afr J Radiol. 2019.
[12] Kim DH et al. Optic nerve sheath diameter by MRI and eyeball size. AJNR. 2019.
[13] Chen HH et al. Microstructural assessment of EOMs using DTI. Neuroradiology. 2019.
[14] Sengupta S et al. Real-time imaging of the eye and EOMs via MRI. Magn Reson Imaging. 2019.
[15] Kızılgöz O et al. Standardized MRI-based orbital structure measurements. J Radiol Case Rep. 2024.
[16] Safak NK et al. Assessment of normal orbital structure measurements in adults. Radiol Med. 2024.
[17] Asmat F et al. MRI evaluation of orbital structures in pediatrics. J Pediatr Ophthalmol Strabismus. 2023.
[18] Gala F. Magnetic Resonance Imaging of the Optic Nerve. Radiographics. 2021.
[19] Chow LS et al. Advances in optic nerve MRI and post-processing. Magn Reson Imaging Clin N Am. 2021.
[20] Nguyen BN et al. Ultra-high-field MRI of retrobulbar optic nerve. Invest Ophthalmol Vis Sci. 2021.
[21] Moon Y et al. Diffusion MRI tractography of optic nerve in elderly. Neuroimage Clin. 2021.
[22] Becker M et al. Imaging of optic nerve disorders: a review. Eur Radiol. 2019.
[23] Clark RA et al. MRI of globe–tendon interface in EOMs. Invest Ophthalmol Vis Sci. 2018.
[24] Loba P et al. Morphometric analysis of rectus muscles using MRI. Clin Radiol. 2015.
[25] Demer JL et al. T2-weighted MRI of extraocular muscles. Am J Ophthalmol. 2011.