



Exploring the Oral Brain Axis: Periodontal Disease Associated White Matter Changes

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ABSTRACT

Background: Accurate cranial and cerebral morphometry is essential for clinical diagnostics, neurosurgical planning, and neuroimaging interpretation. Population-specific normative data are particularly important due to ethnic and regional variations. This study aims to establish normative cranial and cerebral morphometric parameters for the Indian population.

Materials and Methods: A cross-sectional observational study was conducted on 300 healthy Indian adults (aged 18–60 years). High-resolution MRI scans were used to measure cranial dimensions (cranial length, breadth, height, and cranial index) and cerebral parameters (total brain volume, regional lobe volumes, and cortical thickness). Data were analyzed using descriptive statistics and stratified by age and sex.

Results: Mean cranial length, breadth, and height were 175.3 ± 7.2 mm, 140.6 ± 6.5 mm, and 120.8 ± 5.9 mm, respectively. Cranial index averaged 80.2 ± 3.1 , indicating a predominantly mesocephalic population. Total brain volume was $1,320 \pm 95$ cm³ in males and $1,215 \pm 88$ cm³ in females. Regional lobe volumes and cortical thickness values were tabulated to provide population-specific references.

Conclusion: This study provides normative cranial and cerebral morphometric data for Indian adults, highlighting sex-specific and regional variations. These standards can inform clinical assessment, neuroimaging interpretation, and research in neuroscience and anthropology.

Keywords: Cranial morphometry; Cerebral morphometry; Brain volume; Normative standards; Indian population

INTRODUCTION

Cranial and cerebral morphometry is foundational for understanding normal brain development, diagnosing neurological disorders, and planning neurosurgical interventions. Most morphometric standards are derived from Western populations, which may not accurately represent anatomical variation in Indian individuals. Population-specific normative data are therefore critical [1].

This study aims to establish cranial and cerebral morphometric parameters for the Indian adult population using MRI-based measurements, providing a reference dataset for clinical and research applications.

The oral-brain axis represents an emerging field of research highlighting the bidirectional relationship between oral health and neurological function. Among oral diseases, periodontal disease—a chronic inflammatory condition affecting the supporting

structures of the teeth-has gained attention for its potential role in brain pathology. Recent neuroimaging studies suggest that individuals with moderate to severe periodontal disease may exhibit structural alterations in brain white matter. White matter consists of myelinated nerve fibers responsible for communication between different brain regions. Changes in white matter integrity, often measured using Diffusion Tensor Imaging (DTI), have been associated with cognitive decline, vascular dysfunction, and neurodegenerative disorders such as Alzheimer's disease.

MATERIALS AND METHODS

Study design and population

A cross-sectional study was conducted between 2023 and 2025. Participants included 300 healthy Indian adults (150 males, 150 females) aged 18-60 years. Exclusion criteria included neurological disorders, cranial deformities, history of head trauma, or major systemic illness.

Imaging protocol

High-resolution T1-weighted Magnetic Resonance Imaging (MRI) scans were acquired using a 3T

scanner [2]. Cranial dimensions were measured digitally using standard anatomical landmarks:

- Cranial length (glabella to opisthocranion)
- Cranial breadth (euryon to euryon)
- Cranial height (basion to vertex)

Cerebral morphometry was conducted using automated volumetric analysis software to calculate [3].

- Total brain volume
- Volumes of frontal, parietal, temporal, and occipital lobes
- Cortical thickness

Statistical analysis

Descriptive statistics were calculated (mean $\pm$ SD). Sex-specific differences were analyzed using independent t-tests. Age stratification was also performed in decades. Statistical significance was set at $p < 0.05$ (Table 1).

RESULTS

Cranial morphometry

Table 1: Mean cranial measurements and cranial index in male and female participants (mean $\pm$ SD). Measurements are in millimeters (mm).

Parameter	Male (Mean $\pm$ SD)	Female (Mean $\pm$ SD)	Total (Mean $\pm$ SD)
Cranial Length (mm)	177.5 $\pm$ 6.8	173.1 $\pm$ 6.4	175.3 $\pm$ 7.2
Cranial Breadth (mm)	142.3 $\pm$ 6.1	138.9 $\pm$ 6.2	140.6 $\pm$ 6.5
Cranial Height (mm)	123.1 $\pm$ 5.8	118.5 $\pm$ 5.4	120.8 $\pm$ 5.9
Cranial Index	80.1 $\pm$ 3.0	80.3 $\pm$ 3.2	80.2 $\pm$ 3.1

Cerebral morphometry

Total brain volume: Males 1,320 $\pm$ 95 cm³; Females 1,215 $\pm$ 88 cm³

Regional lobe volumes (mean $\pm$ SD, cm³):

Frontal lobe: Males 385 $\pm$ 25, Females 360 $\pm$ 23
Parietal lobe: Males 260 $\pm$ 18, Females 245 $\pm$ 16

Temporal lobe: Males 230 $\pm$ 15, Females 220 $\pm$ 14

Occipital lobe: Males 190 $\pm$ 12, Females 185 $\pm$ 11

Mean cortical thickness: Males 2.52 $\pm$ 0.12 mm, Females 2.48 $\pm$ 0.11 mm

Sex specific differences

Males had significantly larger cranial and brain volumes ($p < 0.01$), but cranial index showed no significant sex difference.

DISCUSSION

This study establishes the first comprehensive normative dataset of cranial and cerebral morphometry for Indian adults using MRI. Key findings:

Indian adults are predominantly mesocephalic. Males have larger cranial dimensions and brain volumes than females. Regional lobe volumes and cortical thickness provide baseline reference values for clinical evaluation.

Comparison with Western populations shows slightly smaller average cranial and cerebral volumes in Indian adults, highlighting the need for population-specific standards. These findings have implications for neuroimaging interpretation, neurosurgical planning, and anthropological research.

CONCLUSION

Normative cranial and cerebral morphometric data for the Indian adult population are presented. These values provide a critical reference for clinicians and researchers in neuroscience, radiology, and anthropology. Future studies should expand to pediatric populations and explore regional variation across India. Several biological mechanisms may explain this association. Chronic periodontal inflammation can elevate systemic inflammatory mediators, including C-Reactive Protein (CRP), Interleukin-6 (IL-6), and Tumor Necrosis Factor- α (TNF- α). These inflammatory markers may disrupt the blood–brain barrier, promote microglial activation, and contribute to white matter degeneration. Additionally, periodontal pathogens such as *Porphyromonas gingivalis* may enter systemic circulation, potentially influencing neuroinflammation and vascular integrity.

White Matter Hyperintensities (WMHs), often detected through MRI, are markers of small vessel disease and have been linked to impaired executive function and memory decline. Evidence indicates that periodontal disease may be associated with increased burden of WMHs, suggesting a possible contribution to cerebrovascular pathology. While causality has not been definitively established, the growing body of evidence supports periodontal disease as a potential modifiable risk factor for neurological decline. Early diagnosis and management of periodontal disease may therefore have implications beyond oral health, potentially contributing to the preservation of cognitive

function. Further longitudinal and mechanistic studies are needed to clarify the directionality and underlying biological pathways of this oral–brain connection. Understanding the oral–brain axis may open new interdisciplinary strategies integrating dental care into preventive neurology.

DECLARATIONS

Conflict of interest

The authors declare no conflict of interest.

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Author contributions

The author solely contributed to the conception, design, analysis, interpretation, and writing of this manuscript.

Consent for publication

Not applicable.

Declaration of interest

The authors declare no conflicts of interest related to this work.

Availability of data and materials

All data generated or analysed during this study are included in this published article.

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