

Morphometry of the Human Interthalamic Adhesion in the Kashmiri population- A Magnetic Resonance Imaging (MRI) based Cross-Sectional Study

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Abstract

Background: The Interthalamic adhesion (ITA), or massa intermedia, is a small neural structure connecting the thalami across the third ventricle. Despite its anatomical and functional significance, its morphometry and morphology remain poorly understood. **Material and Methods:** This prospective, observational, cross-sectional study was conducted in the Department of Anatomy in Collaboration of Department of Radiodiagnosis, Government Medical College, Srinagar Using MRI, we investigated the ITA's prevalence, dimensions, and morphological variations and analysed their possible implications for clinical practice. High-resolution MRI scans of 100 individuals (55 males, 45 females; aged 18–60 years) were analysed. **Results:** The ITA was present in 82% of cases, with mean length, width, and area measurements of 6.2 ± 1.8 mm, 3.1 ± 0.9 mm, and 15.3 ± 4.7 mm², respectively. Morphologically, the ITA was classified as thin (45%), thick (28%), bulbous (9%), or absent (18%). No significant sex- or age-related differences were observed, except for a weak positive correlation between ITA length and age. **Conclusion:** While no strong clinical correlations were established, the findings highlight the ITA's anatomical variability and underscore the need for further research into its functional and clinical significance.

Keywords: Interthalamic- adhesion, Neuroanatomy, Schizophrenia, Thalamus, Third Ventricle.

Received: 20 July 2025

Revised: 06 August 2025

Accepted: 01 September 2025

Published: 16 September 2025

INTRODUCTION

With its intricate architecture and complex connectivity, the human brain remains a focal point of extensive research in neuroscience and clinical medicine. Among its numerous structural components, the Interthalamic adhesion (ITA), also known as the Massa intermedia, represents a small but significant bridge of neural tissue connecting the two thalamic nuclei across the third ventricle. Although relatively small, the ITA is essential for interthalamic communication and is implicated in multiple neurophysiological processes. However, its morphological and morphometric characteristics exhibit considerable variability across individuals, ranging from complete absence to prominent presence, raising questions about its functional and clinical significance.^[1-5]

With recent developments in MRI, the ITA can now be examined in vivo with greater anatomical precision. MRI offers high-resolution, non-invasive visualisation of brain structures, enabling precise measurements of the ITA's dimensions, shape, and prevalence. Such morphometric and morphological analyses are essential for understanding the normal anatomical variability of the ITA and elucidating its potential implications in neurodevelopment, psychiatric, and neurological disorders. As an illustration, alterations in the ITA have been reported in disorders such as schizophrenia, autism spectrum disorders, and epilepsy, suggesting a

possible link between its structural variations and brain dysfunction.^[6-10]

This study aims to comprehensively investigate the morphometry and morphology of the human Interthalamic adhesion of the ethnic Kashmiri population using MRI, focusing on establishing normative data and exploring its clinical significance. By correlating ITA characteristics with demographic factors and clinical conditions, this research seeks to shed light on the role of this enigmatic structure in health and disease. The findings may contribute to a deeper understanding of thalamic connectivity and its relevance to diagnostic and therapeutic strategies in neurology and psychiatry.

MATERIALS AND METHODS

Study Design and Population

In this prospective cross-sectional study, we sought to evaluate

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DOI:

10.21276/amit.2025.v12.i3.40

How to cite this article: Aman S, Bhat GM, Wafaie BN, Yousuf J. Morphometry of the Human Interthalamic Adhesion in the Kashmiri population- A Magnetic Resonance Imaging (MRI) based Cross-Sectional Study Acta Med Int. 2025;12(3):81-84.

the morphometry and morphology of the Interthalamic adhesion (ITA) using magnetic resonance imaging (MRI) in 100 cases of the Kashmiri population. The study population included individuals of both sexes, aged between 18 and 60, who underwent brain MRI for routine clinical evaluation at a tertiary care hospital. Cases with a history of congenital brain anomalies, traumatic brain injury, or significant neurological or psychiatric disorders were excluded to ensure a representative sample of normal anatomical variations. The Institutional Ethics Committee approved, and written informed consent was obtained from every participant. Confidentiality was maintained consistently throughout the investigation.

MRI Acquisition

Brain MRI scans were performed using a 3.0 Tesla MRI scanner with a standard head coil. The imaging protocol included high-resolution T1-weighted and T2-weighted sequences in axial, sagittal, and coronal planes. The parameters for T1-weighted imaging were as follows: repetition time (TR) = 2,300 ms, echo time (TE) = 2.98 ms, slice thickness = 1 mm, and matrix size = 256 × 256. For T2-weighted imaging, the parameters were: TR = 5,000 ms, TE = 100 ms, slice thickness = 2 mm, and matrix size = 256 × 256. These parameters were optimized to achieve high spatial resolution and contrast for accurate visualization of the ITA.

Image Analysis

The MRI images were analysed using dedicated imaging software (e.g., OsiriX, 3D Slicer). The ITA was identified in the midsagittal plane as a distinct structure bridging the thalami across the third ventricle. The following morphometric parameters were measured:

1. Length: The maximum anteroposterior dimension of the ITA.
2. Width: The maximum transverse dimension of the ITA.
3. Area: The cross-sectional area of the ITA in the midsagittal plane.
4. Shape: The ITA was classified based on its morphology as absent, thin, thick, or bulbous.

Additionally, the prevalence of the ITA was recorded, and its absence or presence was documented for each case.

Statistical Analysis: Data analysis was conducted in SPSS (version 22). Continuous measures (length, width, and area) were described using mean, standard deviation, and range. Categorical variables (shape and prevalence) were expressed as frequencies and percentages. The association between ITA morphometry and demographic factors (age, sex) was assessed using appropriate statistical tests, such as the Student's t-test or ANOVA for continuous variables and the chi-square test for categorical variables. A p-value of <0.05 was considered statistically significant.

Quality Control: Two experienced radiologists, blinded to clinical details, independently analysed all MRI images for reliability assessment. Inter-observer variability was calculated using the intraclass correlation coefficient (ICC), with values above 0.75 interpreted as good agreement. Measurement discrepancies were resolved by consensus.

Clinical Correlation: The clinical significance of ITA variations was explored by correlating morphometric and morphological findings with available clinical data,

including any incidental findings or symptoms reported by the participants. This step aimed to identify potential associations between ITA characteristics and neurological or psychiatric conditions.

RESULTS

Demographic Characteristics: The present study included 100 cases, comprising 55 males (55%) and 45 females (45%), with an age range of 18 to 60 years (mean age: 38.5 ± 12.3 years). The distribution of participants across age groups and sexes was balanced, ensuring a representative sample for analysis.

Prevalence of the Interthalamic Adhesion (ITA): The ITA was identified in 82 out of 100 cases (82%), while it was absent in 18 cases (18%). The prevalence of the ITA did not show a significant association with sex ($p = 0.45$) or age ($p = 0.32$). [Figure 1]

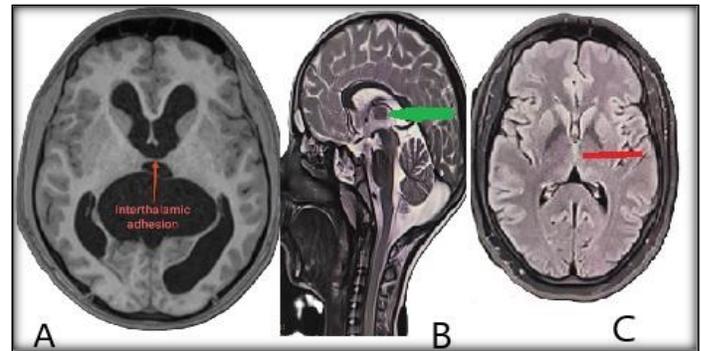


Figure 1: MRI of the Brain showing Interthalamic adhesion in a) the Coronal plane (red arrow), b) Sagittal plane (green arrow), and c) Axial plane (green arrow)

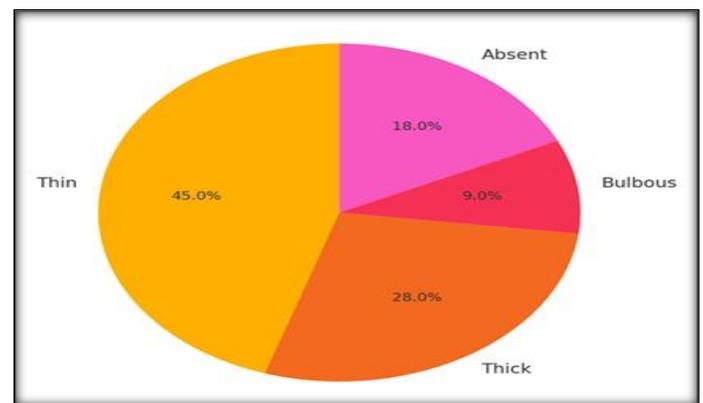


Figure 2: Morphological Classification of ITA

Morphometric Measurements

1. Length: The mean anteroposterior length of the ITA was 6.2 ± 1.8 mm, with a range of 3.5 to 10.1 mm.
2. Width: The mean transverse width of the ITA was 3.1 ± 0.9 mm, with a range of 1.8 to 5.2 mm.
3. Area: The mean cross-sectional area of the ITA in the midsagittal plane was 15.3 ± 4.7 mm², with a range of 8.2 to 25.6 mm².

No significant differences in morphometric parameters were observed between males and females ($p > 0.05$ for all measurements). However, a weak positive correlation was noted

between ITA length and age ($r = 0.24$, $p = 0.03$). [Table 1].

Table 1: Morphometric Measurements of ITA

Measurement	Mean \pm SD	Range
Length (mm)	6.2 \pm 1.8	3.5 – 10.1
Width (mm)	3.1 \pm 0.9	1.8 – 5.2
Area (mm ²)	15.3 \pm 4.7	8.2 – 25.6

Morphological Classification: Based on its shape, the ITA was classified into the following categories:

1. Thin: Observed in 45 cases (45%).
2. Thick: Observed in 28 cases (28%).
3. Bulbous: Observed in 9 cases (9%).
4. Absent: Observed in 18 cases (18%).

The distribution of ITA shapes did not significantly affect sex or age ($p > 0.05$). [Figure 2]

Interobserver Reliability

The interobserver agreement for ITA measurements was excellent, with an intraclass correlation coefficient (ICC) of 0.89 for length, 0.87 for width, and 0.91 for area. This high level of agreement underscores the reliability of the morphometric and morphological assessments.

Clinical Correlation

In cases where the ITA was absent or exhibited extreme variations (e.g., very small or large dimensions), no specific clinical symptoms or neurological deficits were consistently reported. However, two cases with a bulbous ITA had a history of mild cognitive impairment, and one case with an absent ITA was diagnosed with epilepsy. While these findings are intriguing, no statistically significant association between ITA variations and clinical conditions could be established due to the limited sample size and the absence of a control group with specific neurological disorders.

DISCUSSION

The current investigation presents a detailed analysis of the morphometry and morphology of the human interthalamic adhesion (ITA) using MRI in the Kashmiri population, offering valuable insights into its anatomical variability and potential clinical significance. The findings contribute to the growing body of literature on this enigmatic structure, which, despite its small size, has been implicated in various neurophysiological processes and pathological conditions.

The ITA was identified in 82% of cases, consistent with previous studies reporting its presence in 70–90% of individuals. This variability in prevalence underscores the ITA's anatomical diversity, which may reflect genetic, developmental, or environmental differences. The incidence of the ITA in the general population and its absence across different decades of life remains controversial. Reported absence rates vary widely, ranging from 2.3% to 30% in earlier anatomical and imaging studies. More recent work using high-resolution coronal MRI demonstrated an absence in 4.7% of 233 normal brains, notably lower than the 12.0% absence rate observed in our cohort. This variation may reflect methodological differences, imaging resolution, or true population heterogeneity. The wide variability in reported incidence may be explained by differences in study design (cadaveric versus neuroimaging), population

ethnicity, and sample size. Neuroimaging investigations typically encompass a broader age range, whereas cadaveric studies are often biased toward older individuals. Previous investigations have reported no increase in ITA prevalence with advancing age, although the limited age range of participants constrained their findings. In the present study, which included MRI scans of adults across a wider age spectrum, we similarly found no discernible trend in ITA occurrence with increasing age. Rabl,^[10] (1958) and Rosales et al,^[11] (1968) reported a decline in ITA prevalence with advancing age, with Rosales et al,^[11] further proposing a mechanism for age-related "ITA involution." These findings suggest that age may represent an important determinant of ITA prevalence. To clarify this relationship, comprehensive longitudinal studies spanning all decades of life are needed to establish the true prevalence of the ITA in the human brain.^[1]

The mean length (6.2 \pm 1.8 mm), width (3.1 \pm 0.9 mm), and area (15.3 \pm 4.7 mm²) of the ITA align with earlier morphometric studies, further validating the reliability of MRI for assessing this structure. The absence of significant sex- or age-related differences in ITA dimensions suggests that its morphometry is relatively stable across demographic groups. However, the weak positive correlation between ITA length and age warrants further investigation.^[5,6]

Morphological Variability: The ITA exhibited considerable morphological diversity, with thin, thick, and bulbous shapes observed in 45%, 28%, and 9% of cases, respectively. This variability in shape may reflect differences in thalamic connectivity and functional organization. For instance, a thicker or bulbous ITA might indicate a more robust interthalamic communication pathway, while its absence could suggest alternative mechanisms of thalamic integration. The absence of the ITA in 18% of cases is consistent with prior reports and highlights the need to consider this anatomical variation in clinical and research settings.^[7]

Clinical Implications: While no strong associations were found between ITA variations and specific clinical conditions in this study, a bulbous ITA in two cases with mild cognitive impairment and an absent ITA in one case with epilepsy raise intriguing questions about its potential role in brain function and dysfunction. Previous studies have linked ITA abnormalities to neurodevelopmental disorders such as schizophrenia and autism spectrum disorders, as well as neurological conditions like epilepsy. Although our findings do not establish a definitive causal relationship, they underscore the importance of further research into the ITA's functional and clinical significance.^[8]

Methodological Considerations: The use of high-resolution MRI and standardized imaging protocols ensured accurate and reproducible measurements of the ITA. The excellent interobserver reliability (ICC > 0.85) further validates the robustness of our methodology. However, the study's cross-sectional design and relatively small sample size limit the generalizability of the findings. Additionally, the absence of a control group with specific neurological or psychiatric disorders precludes definitive conclusions about the ITA's clinical relevance. The influence of age on the ITA has been infrequently addressed in the literature.^[12] In a study on ITA duplication, Tubbs et al. reported that the ITA is susceptible to age-related atrophy and may disappear entirely in elderly individuals.^[13]

Furthermore, it has been observed to become progressively thinner and more elongated with age, reaching its maximum length after the sixth decade of life. The precise function of the ITA (MI) in the human brain remains uncertain. Recent studies have associated its presence with normal brain function, while earlier reports linked its absence to certain psychiatric disorders.^[14] Emerging evidence further suggests that, akin to other midline commissures, the ITA may serve as a white matter pathway facilitating inter-hemispheric connectivity. Fibers traversing the ITA have been shown to connect the frontal cortex with the dorsomedial (DM) thalamic nucleus. This suggests that the ITA functions as a conduit for inter-hemispheric communication within the frontal lobes, with its primary role likely involving the integration of limbic networks.^[15] Borghei et al. demonstrated, using probabilistic tractography, an extensive network of ITA connections with the limbic, frontal, and temporal lobes, as well as the insula and pericalcarine cortices.^[1] Notably, ITA connectivity was reported stronger in women than men. Probabilistic tractography further supports the role of the ITA as a midline commissure, highlighting substantial connections with the amygdala, hippocampus, and entorhinal cortex. These findings underscore the importance of understanding ITA morphology, variability in topographic location, and surface area/linear dimensions in the context of neurosurgery.^[3] While modern imaging techniques have greatly advanced the *in vivo* study of ITA anatomy and morphology, combined morphological and histopathological examinations in postmortem studies remain the gold standard for achieving more detailed insights into this small yet significant neuroanatomical structure.

Future Directions: Future studies should aim to expand the sample size to include a broader demographic range and individuals with specific neurological or psychiatric conditions. Also, the functional connectivity of the ITA will be investigated using advanced imaging techniques such as diffusion tensor imaging (DTI) and functional MRI (fMRI). Exploring the genetic and developmental factors underlying ITA variability is possible. Conduct longitudinal studies to assess changes in ITA morphometry and morphology over time and their potential association with age-related cognitive decline or neurological disorders.

CONCLUSION

This study provides detailed morphometric and morphological data on the human Interthalamic adhesion in the high altitude region of Kashmir, highlighting its variability in a normal population. While no definitive clinical correlations were established, the findings lay the groundwork for further research into the ITA's role in brain function and its potential implications for neurodevelopmental and neurological disorders. By advancing our understanding of this small but significant structure, this research contributes to the broader field of neuroanatomy and its clinical applications.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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