Section: Anatomy

Original Research Article

UNDERSTANDING MORPHOLOGICAL VARIABILITY IN THE CAUDAL END BRANCHES OF THE SUPERIOR TEMPORAL SULCUS: A STUDY ON HUMAN CADAVERIC BRAINS IN ASSAM, INDIA

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Abstract

Background: The Superior Temporal Sulcus is a prominent feature of the brain's lateral surface, playing a crucial role in various cognitive processes. Despite its significance, the morphological variability of the Caudal end Branches of the Superior Temporal Sulcus remains underexplored. This study aims to investigate the anatomical variances in the Caudal end Branches of the Superior Temporal Sulcus, emphasizing their associations with surrounding sulci and gyri. **Materials and Methods:** A cross-sectional pilot study was conducted on 25 whole brains (50 hemispheres) sourced from embalmed adult human cadavers. The Superior Temporal Sulcus and its Caudal end Branches were meticulously examined using established anatomical landmarks and 3-D planes during precise dissection. Three observers ensured reliability, and inclusion/exclusion criteria were strictly followed. **Result:** The study identified distinct Anterior, Central, and Posterior branches of the Superior Temporal Sulcus, with varying frequencies and distributions across hemispheres. Notable variations were observed in the proximity of these branches to surrounding landmarks, such as the intraparietal sulcus and pre-occipital sulcus. Our findings align with previous research, highlighting the asymmetry and variability of the Superior Temporal Sulcus Branches. These results have implications for neurosurgical planning, functional neuroimaging, and clinical applications related to language and auditory processing and neurodevelopmental disorders. The study's limitations include sample characteristics, exclusion criteria, methodological constraints, inability to assess functional correlates, and lack of longitudinal data. **Conclusion:** This study provides valuable insights into the morphological variability of the Caudal end Branches of the Superior Temporal Sulcus, contributing to our understanding of this complex anatomical feature. Future research should validate these findings in living subjects and explore their functional significance further.

INTRODUCTION

The lateral surface of the temporal lobe features two prominent sulci, namely the Superior and Inferior Temporal sulci. Among these, the Superior Temporal Sulcus stands out as a significant feature of the brain's lateral aspect.[1] It is well-defined and exhibits considerable depth, originating at the temporal pole and extending to terminate within the inferior parietal lobule, situated posteriorly to the end of the lateral fissure. The Superior Temporal Sulcus can be subdivided into four distinct parts based on its parcellation: Superior Temporal Sulcus (dorsal anterior), Superior Temporal Sulcus (dorsal posterior), Superior Temporal Sulcus (ventral anterior), and Superior Temporal Sulcus (ventral posterior). The Caudal end Branches or Rami of the Superior Temporal Sulcus display notable morphological variability among individuals.[2] Known for its multifaceted functions, the Superior Temporal Sulcus contributes to processes such as motion perception, speech and facial processing, language comprehension, and audio-visual integration.[3] Consequently, understanding the morphology of the Caudal end Branches of the Superior Temporal Sulcus holds significance for neurological diagnosis and management.[4-8]
This study seeks to investigate the anatomical variances observed in the Caudal end Branches of the Superior Temporal Sulcus in both hemispheres, with a particular emphasis on their associations with surrounding sulci and gyri. These investigations are

imperative for advancing contemporary functional and structural neuroimaging studies.[9-16]

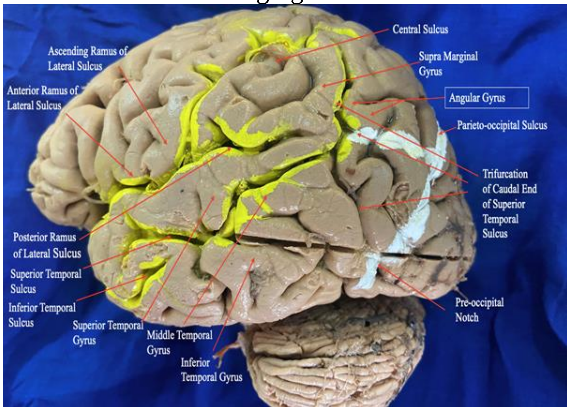

Figure 1: Brain Specimen with Anatomical Landmarks.[10,17]

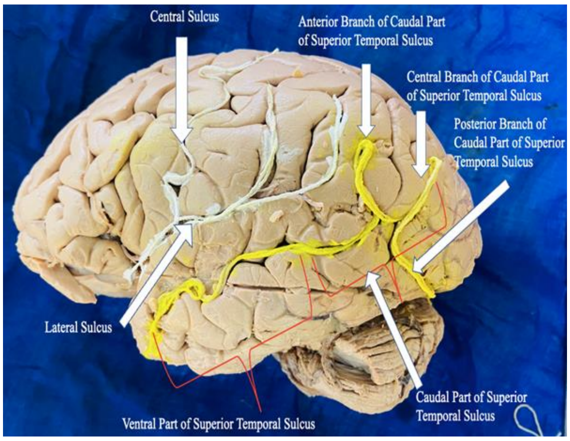

Figure 2: Caudal end Rami of the Superior Temporal Sulcus.[10,17]

MATERIALS AND METHODS

A cross-sectional pilot study was conducted on 25 whole brains (50 hemispheres) sourced from embalmed adult human cadavers, obtained from the Department of Anatomy and the Department of Forensic Medicine & Toxicology at Gauhati Medical College and Hospital, Guwahati, India, spanning from May 2021 to August 2023. These cadavers, acquired from diverse regions of the state, were either donated for educational purposes or utilized for medicolegal investigations. Identification of the Superior Temporal Sulcus on the superolateral surface of the brain was performed with reference to established landmarks, including the posterior rami of the Sylvian fissure, inferior parietal lobule, and pre-occipital sulci. The origin and termination of each Caudal end Branches of the Superior Temporal Sulcus were meticulously examined using sulcal depth, employing 3-D planes (e.g., sagittal, coronal, and horizontal planes) during precise dissection of each sulcus and its corresponding gyri. Three observers were involved to mitigate interobserver variability, and the average findings were considered for inclusion in the results.

RESULTS

Approximately 30% of cases exhibited the presence of the Anterior Branch, situated within the inferior parietal lobule, just posterior to the ascending limb of the Sylvian fissure—a prominent gross anatomical landmark. Within 18% of hemispheres (20% right, 16% left), the Anterior Branch nearly extended dorsally toward the intraparietal sulcus; however, definitive continuity into the intraparietal sulcus was not established. Similarly, in 12% of hemispheres (8% right, 16% left), the Anterior Branch nearly approached the termination of the Sylvian fissure, yet actual contact (sulcal depth) could not be confirmed, despite superficial indications of its presence.

The Central Branch was identified in approximately 60% of cases and typically located between the Anterior and Posterior Branches of the Superior Temporal Sulcus. In 12% of hemispheres (8% right, 16% left), the Central Branch nearly extended dorsally toward the intraparietal sulcus, but continuity into the intraparietal sulcus could not be established. Notably, in 50% of hemispheres (48% right, 54% left), the Caudal end Branches of the Superior Temporal Sulcus continued as the central branch.

Approximately 14% of cases displayed the presence of the Posterior Branch, positioned posteriorly to the central branch. No horizontally connecting (i.e., annectant) sulci were observed between the two branches. Within 14% of hemispheres (16% right, 12% left), the Posterior Branch nearly approached the pre-occipital sulcus, another significant gross anatomical landmark."

Table 1: Inclusion and Exclusion Criteria

Sl No.	Inclusion Criteria	Exclusion Criteria
1.	Cadavers donated for educational or medicolegal purposes, irrespective of age and gender, sourced from various regions of the state.	Morphologically damaged specimens (with pathological lesions and developmental anomalies) and brains subjected to post-mortem manipulation.

Table 2: Summary of Superior Temporal Sulcus Caudal End Branches Morphology

Parameters	Right Hemispheres (25)(%)	Left Hemispheres (25) (%)	Bilateral Hemispheres (50) (%)
1. Anterior branch approaching the intraparietal sulcus	5(20%)	4(16%)	9(18%)
2. Anterior branch approaching the termination of Sylvian fissure	2(8%)	4(16%)	6(12%)

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3. Central branch approaching the intra parietal sulcus	2(8%)	4(16%)	6(12%)
4. Posterior branch approaching the pre occipital sulcus	4(16%)	3(12%)	7(14%)
5. Presence of all the Caudal end Branches	4(16%)	3(10%)	7(14%)
6. Presence of only Anterior branch	Nil	Nil	Nil
7. Presence of only Central branch	12(48%)	13(54%)	25(50%)
8.Presence of only Posterior branch	Nil	Nil	Nil

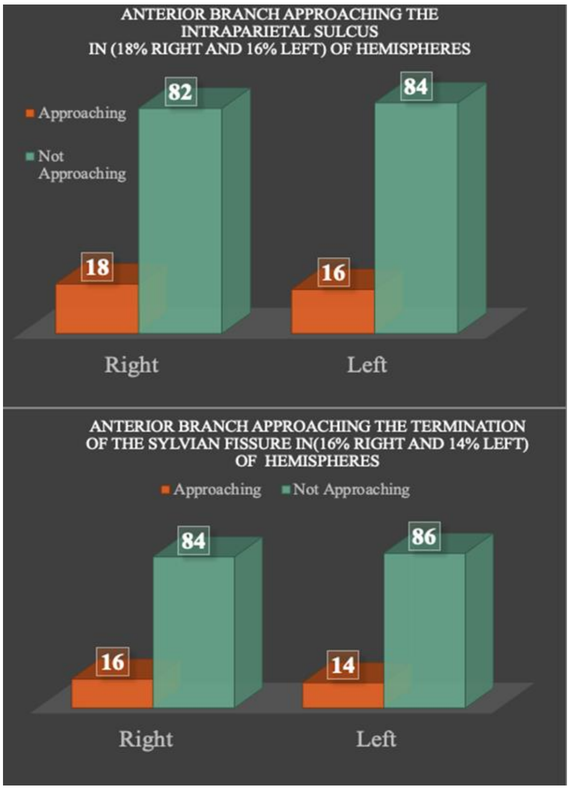

Figure 3: Distribution of Anterior Branch Variations Across Hemispheres

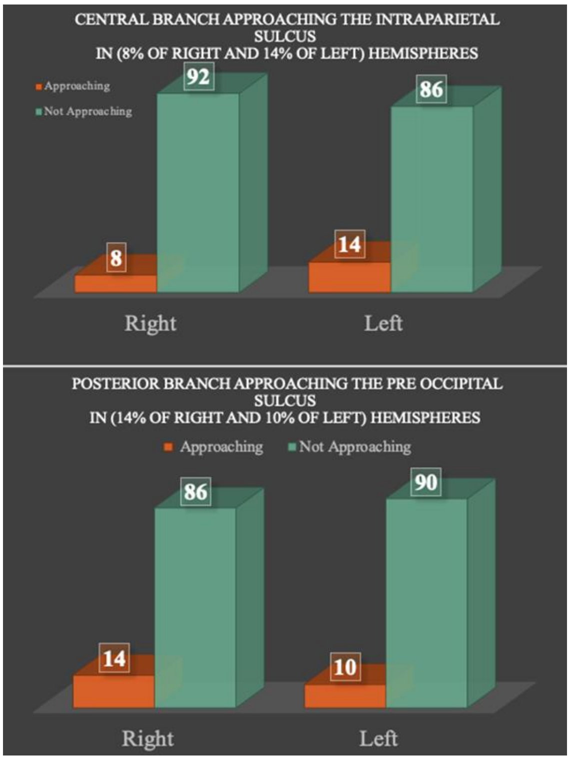

Figure 4: Distribution of Central and Posterior Branch Variations Across Hemispheres

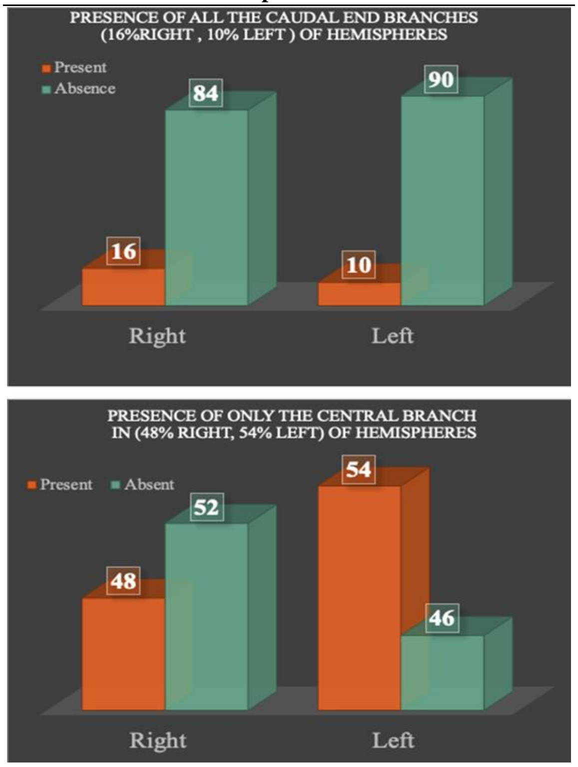

Figure 5: Distribution of All Caudal End Branches and Only Central Branch Variations Across Hemispheres

DISCUSSION

Our study aimed to investigate the morphological variability of the Caudal end Branches of the Superior Temporal Sulcus (STS) in human cadaveric brains from Assam, India. Our findings shed light on the anatomical nuances of this region, with implications for neuroanatomical understanding, surgical planning, and functional neuroimaging. Our results align with previous research by Segal and Petrides et al. (2012), who also identified distinct Anterior, Central, and Posterior branches of the Superior Temporal Sulcus (STS). The variability in the location and extent of these branches has been documented in other studies as well (Leroy et al., 2015; Ochiai et al., 2004). Additionally, our findings corroborate reports of asymmetry in the Caudal end Branches of the Superior Temporal Sulcus (STS), with branches appearing more posteriorly in the left hemisphere compared to the right (Segal and Petrides et al., 2012).[18-20]

Implications of the findings include:

1. Neurosurgical Planning: The precise knowledge of Superior Temporal Sulcus morphology is crucial for neurosurgeons planning interventions in the inferior parietal lobule and surrounding areas. Variations in Superior Temporal Sulcus branches could affect the risk of damage to critical structures during surgery (Gars et al., 2009; Taylor & Probst, 2008).

2. Functional Neuroimaging: Functional neuroimaging techniques such as fMRI rely on accurate anatomical landmarks for mapping brain activity. Understanding Superior Temporal Sulcus variability can enhance the interpretation of functional imaging data and aid in localizing specific brain functions (Thompson et al., 1996).

3. Clinical Applications: Abnormalities in the Superior Temporal Sulcus have been implicated in various neurological disorders, including epilepsy and auditory processing disorders (Hein & Knight, 2008). Our study's findings could contribute to the diagnosis, treatment, and management of such conditions (Kiernan, 2012).

4. Language and Auditory Processing: The proximity of the Superior Temporal Sulcus to brain regions associated with language and auditory processing underscores its importance in these functions. Insights from our study could inform research and interventions aimed at understanding and treating language-related disorders (Hein & Knight, 2008).

5. Neurodevelopmental Disorders: Anomalies in brain development, including variations in sulcal patterns, have been implicated in neurodevelopmental disorders such as autism spectrum disorder and ADHD (Nishikuni & Ribas, 2013). Understanding the normal and variant anatomy of the Superior Temporal Sulcus could contribute to early detection and intervention in such disorders.

6. Neurorehabilitation: Knowledge of Superior Temporal Sulcus Anatomy can aid in the development of targeted rehabilitation strategies for individuals undergoing neurorehabilitation following stroke or traumatic brain injury (Souza et al., 2005).

Limitation(s):

Sample Characteristics: Our study exclusively utilized cadaveric brain specimens sourced from embalmed adult human cadavers. The use of cadaveric specimens may limit the generalizability of our findings to living individuals, as post-mortem changes and preservation methods could affect brain morphology differently from the in vivo state.

Exclusion of Pathological Specimens: Our study excluded morphologically damaged specimens with pathological lesions and developmental anomalies. While this exclusion criterion aimed to ensure the integrity of the specimens, it may have introduced selection bias and limited the representativeness of our sample.

Methodological Constraints: Identification of Superior Temporal Sulcus branches and measurement of sulcal depth relied on manual dissection and observation, introducing the potential for interobserver variability. Despite efforts to mitigate this variability by involving three observers and averaging their findings, subjective judgments may have influenced the results.

Inability to Assess Functional Correlates: Our study focused on anatomical variations in Superior Temporal Sulcus morphology and did not assess functional correlates or clinical outcomes. While anatomical knowledge is fundamental, future research incorporating functional imaging techniques could provide a more comprehensive understanding of the implications of Superior Temporal Sulcus variability.

Lack of Longitudinal Data: Our study design was cross-sectional, providing a snapshot of Superior Temporal Sulcus morphology at a single point in time. Longitudinal studies tracking changes in Superior Temporal Sulcus morphology over time could elucidate developmental trajectories and age-related variations.

Acknowledging these limitations is crucial for interpreting the results accurately and informing future research directions. Despite these constraints, our study contributes valuable insights into the morphological variability of the caudal end branches of the superior temporal sulcus, laying the groundwork for further investigation in this area.

CONCLUSION

This study provides valuable insights into the intricate morphology of the Caudal end Branches of the Superior Temporal Sulcus (STS) within the human brain's inferior parietal lobule. By identifying distinct Anterior, Central, and Posterior Branches, our findings align with previous research and contribute to the comprehensive understanding of this anatomical feature. However, further investigations involving living subjects, coupled with functional MRI analyses and assessments of fluid intelligence, are warranted to validate our observations and explore potential clinical implications. Despite its limitations, this study lays a foundation for future research aimed at elucidating the functional significance of these sulcal structures and their potential role in neuroanatomical variability and cognitive function.

REFERENCES

1. Segal, E., & Petrides , M. (2012). The morphology and variability of the caudal rami of the superior temporal sulcus.
2. Frey, S., Vinton, D., Norlund, R., & Grafton, S. (2005). Cognitive Brain Research, 23(2), 397-405.
3. Leroy, F., et al. (2015). New human-specific brain landmark: the depth asymmetry of superior temporal sulcus.
4. Ochiai, et al. (2004). Sulcal pattern and morphology of the superior temporal sulcus.
5. Knight, B., Scabini, D., Woods, D., & Clayworth, C. (1988). The effects of lesions of superior temporal gyrus and inferior parietal lobe on temporal and vertex components of the human AEP.
6. Kiernan, J. (2012). Anatomy of the Temporal Lobe.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

7. Thompson, A., Schwartz, L., Lin, L., Khan, A., & Toga, A. (1996). Three-Dimensional Statistical Analysis of Sulcal Variability in the Human Brain.
8. Monteagudo, A., & Timor-Tritsch, I. (1997). Development of fetal gyri, sulci and fissures: a transvaginal sonographic study.
9. Hein, K., & Knight, S. (2008). Superior temporal sulcus---it's my area: Or is it?
10. Felten, D., & Shetty, A. (2010). Netter's Atlas of Neuroscience. Saunders ⁄ Elsevier, Philadelphia, PA.
11. Souza, G., Eifuku, T., Tamura, R., Nishijo, H., & Ono, T. (2005). Differential Characteristics of Face Neuron Responses Within the Anterior Superior Temporal Sulcus of Macaques.
12. Nishikuni, K., & Ribas, G. (2013). Study of fetal and postnatal morphological development of the brain sulci.
13. Gars, K., Lejeune, S., & Peltier, J. (2009). Surgical anatomy and surgical approaches to the lateral ventricles.
14. Taylor, S., & Probst, G. (2008). Anatomic localization of the transentorhinal region of the perirhinal cortex.
15. Desimone, R., & Ungerleider, L. (1986). Multiple visual areas in the caudal superior temporal sulcus of the macaque.
16. Kiernan, J., & Barr, M. (2009). Barr's the Human Nervous System: An Anatomical Viewpoint. Wolters Kluwer Health ⁄ Lippincott Williams & Wilkins, Philadelphia, PA.
17. Mai, J., Paxinos, G., & Voss, T. (2007). Atlas of the Human Brain. Elsevier Academic Press, London.
18. Malikovic, A., et al. (2006). Cytoarchitectonic Analysis of the Human Extrastriate Cortex in the Region of V5/MT+: A Probabilistic, Stereotaxic Map of Area hOc5.
19. Ogawa, T., & Inui, T. (2012). Specialization of reach function in human posterior parietal cortex.
20. Lohmann, G., & von Cramon, D. (2000). Automatic labelling of the human cortical surface using sulcal basins. Medical Image Analysis, 4(3), 179.