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Original Article

Radiology Section

Classification of Anatomical Variants of Sylvian Fissure Using MRI: A Retrospective Observational Study

AVINESH VARADANE[1], SUJEETH MARIYAPPAN[2], BALAVAITHEESWAR RAMALINGAM[3], ELAMPARIDHI PADMANABAN[4], UMAMAGESWARI AMIRTHALINGAM[5]

ABSTRACT

Introduction: The Sylvian Fissure (SF), which divides the temporal lobe from the frontal and parietal lobes, is a crucial anatomical landmark in neurosurgery. Magnetic Resonance Imaging (MRI) based data on SF morphological variations in the Indian population remain limited, despite its clinical significance.

Aim: To evaluate and classify anatomical variations of the SF in healthy adults using MRI.

Materials and Methods: The present retrospective observational study was conducted in the Department of Radiodiagnosis at Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India, from January 2025 to June 2025. A total of 325 adults aged between 30 and 60 years were included. Individuals with structural or functional abnormalities of the brain were excluded. Five types (I-V) of SF morphology were identified using T1-weighted axial, coronal, and sagittal images, and hemispheric symmetry was evaluated.

Results: Among the 325 MRI brain scans analysed, Type I and Type II SF morphologies were the most frequently observed in both hemispheres. On the right-side, Type II was the most common pattern {140 (43.1%)}, followed closely by Type I {139 (42.8%)}. On the left-side, Type I predominated {144 (44.3%)}, followed by Type II {138 (42.5%)}. Overall, symmetrical SF morphology was observed in the majority of participants {291 (89.5%)}, while asymmetry was noted in a smaller proportion {34 (10.5%)}.

Conclusion: By establishing normative reference data, these findings strengthen the utility of MRI in preoperative assessment and underscore the relevance of standardised SF classification in neurosurgical and radiological practice.

Keywords: Brain anatomy, Cerebral cortex, Hemispheric asymmetry, Lateral sulcus, Magnetic resonance imaging, Neuroimaging anatomy, Neurosurgical landmarks

INTRODUCTION

The Sylvian Fissure (SF), also known as the lateral sulcus, is a prominent anatomical feature on the superolateral surface of the brain that separates the frontal and parietal lobes from the temporal lobe below. Its distinct shape and location make it an essential surgical gateway, particularly in neurosurgical approaches such as the transsylvian-pterional technique for tumour and aneurysm treatment [1,2]. Additionally, the SF is clinically significant as it houses the middle cerebral artery and its branches. Anatomical variations in the SF such as differences in length, depth, and symmetry have been reported across various populations and age groups. These variations influence surgical outcomes as well as the risk of procedure-related morbidity [3].

Although cadaveric dissection has traditionally been used for anatomical studies, it may not adequately reflect in-vivo morphology or the subtle variations detectable through advanced imaging techniques [4]. The lack of comprehensive MRI based data on SF variations may hinder preoperative planning and increase the risk of surgical complications, such as brain oedema or ischaemic events following neurosurgical procedures [5,6]. The present study systematically analyses anatomical variations of the SF in a healthy population using high-resolution MRI. A thorough understanding of SF variability is essential for neurosurgeons and radiologists to minimise intraoperative risks and optimise surgical strategies.

MATERIALS AND METHODS

The present retrospective observational study was conducted in the Department of Radiodiagnosis at Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India, from January 2025 to June 2025. Ethical approval was taken from the Institutional Ethics Committee (EC/131/2024).

Inclusion and Exclusion criteria: Previously acquired 1.5 Targeted Magnetic Resonance Imaging (TMRI) brain images of individuals aged 30-60 years were included. Images from patients with massive stroke, congenital anomalies, neurological disorders, postoperative changes, or intracranial mass lesions were excluded.

Sample size calculation: Based on a previously reported prevalence of Type IV SF morphology of 29.7% in a study by Maslehaty H et al., the sample size was calculated as 321 and rounded to 325 at a 95% confidence level and 5% absolute precision using Open Epi software [7].

Study Procedure

Data were retrieved from the Picture Archiving and Communication System (PACS) of the Department of Radiodiagnosis. The SF was classified into five subtypes:

Type I: wide and straight SF;

Type II: narrow and straight SF;

Type III: wide SF with herniation of the frontal or temporal lobe;

Type IV: narrow SF with herniation of the frontal or temporal lobe;

Type V: SF with herniation of both frontal and temporal lobes.

Classification was performed using axial, coronal, and sagittal T1-weighted MR images.

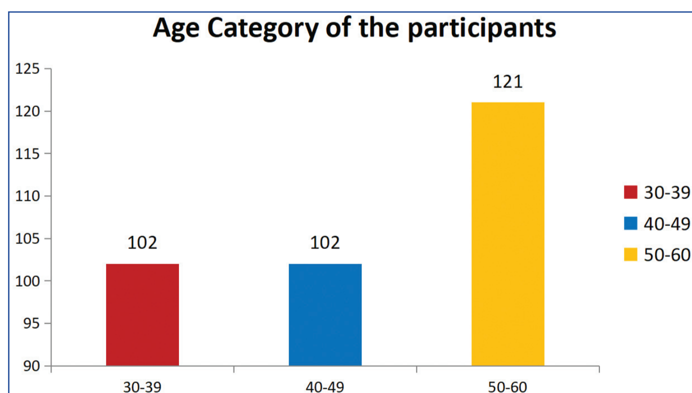
Symmetry was assessed by comparing the SF morphology on the right and left hemispheres in the same individual. Fissures were considered symmetrical when the same SF type (I-V) was present bilaterally, while differing types were classified as asymmetrical.

STATISTICAL ANALYSIS

All data were entered and analysed using Microsoft Excel 2019 and Statistical Package for the Social Sciences (SPSS) version 26.0 (Statistical Package for the Social Sciences, IBM, Armonk, New York, USA). Descriptive statistics, including frequencies and percentages, were used to summarise categorical variables.

RESULTS

The 50-60 year age group constituted maximum of 121 patients, followed by 102 patients in 30-39 and 40-49 age group each [Table/Fig-1]. Male participants constituted a slightly higher proportion of the sample {176 (54.2%)} compared with females {149 (45.8%)}.



[Table/Fig-1]: Age category of the participants (n=325).

On the right hemisphere, Type II fissures were marginally more common {140 (43.1%)} than Type I {139 (42.8%)}, whereas on the left hemisphere, Type I fissures predominated {144 (44.3%)} [Table/Fig-2].

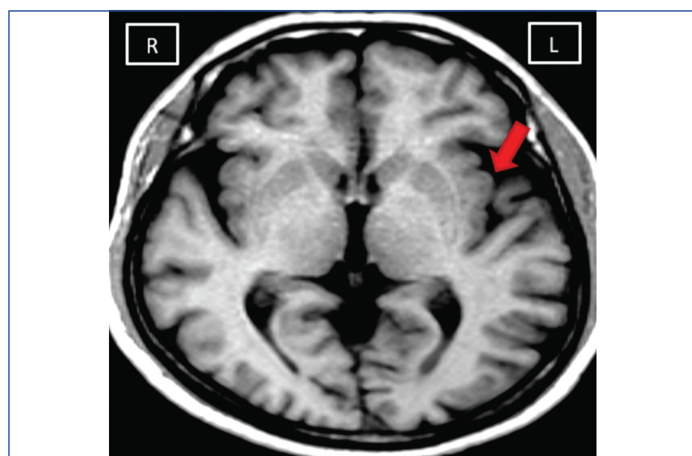
Side of the brain	Type of Sylvian Fissure				
	Type I	Type II	Type III	Type IV	Type V
Right	139 (42.8%)	140 (43.1%)	21 (6.5%)	13 (4%)	12 (3.7%)
Left	144 (44.3%)	138 (42.5%)	23 (7.1%)	11 (3.4%)	9 (2.8%)

[Table/Fig-2]: Distribution of types of SF on right and left-sides of the brain.

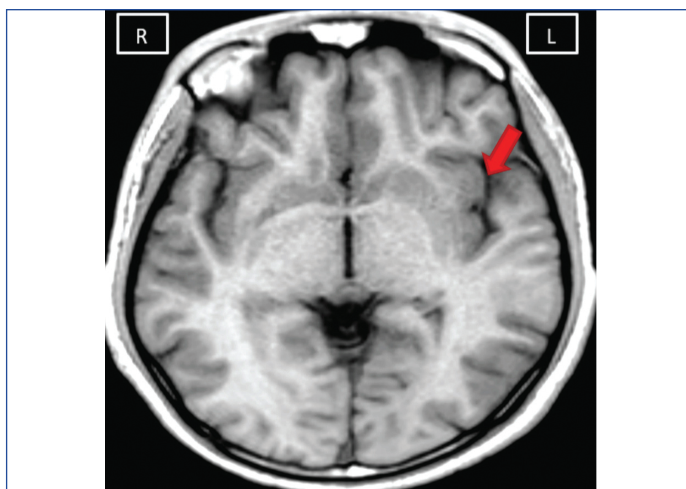
Of the 325 MRI images retrieved from the PACS, 34 individuals (10.5%) demonstrated asymmetrical fissures, while 291 (89.5%) exhibited symmetrical SF morphology between the right and left hemispheres [Table/Fig-3]. [Table/Fig-4-8] illustrate representative images of the different SF types.

Types of SF	Frequency	Percentage
Asymmetrical	34	10.5
Symmetrical	291	89.5

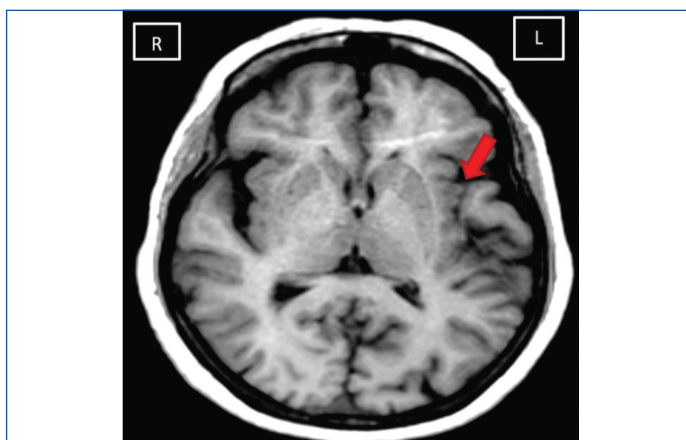
[Table/Fig-3]: Distribution of symmetrical and asymmetrical SF morphology.



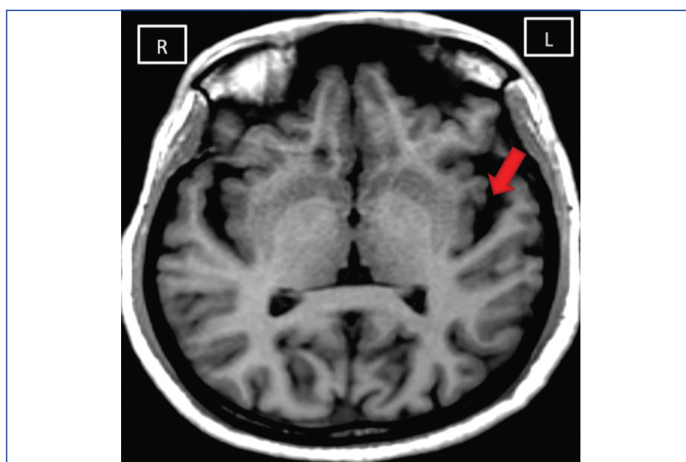
[Table/Fig-4]: MRI image of type I SF.



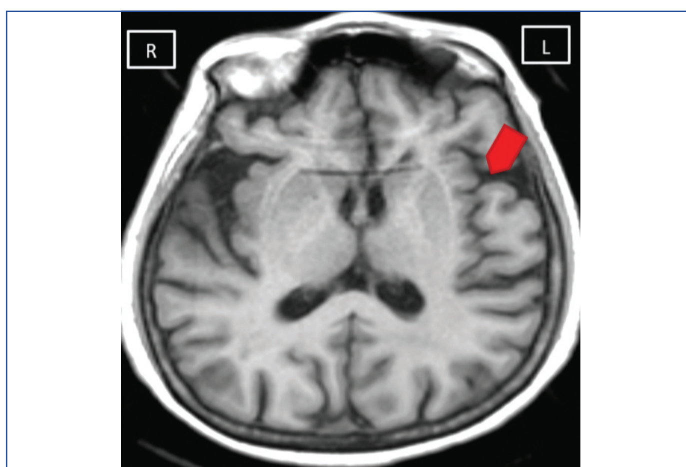
[Table/Fig-5]: MRI image of Type II SF.



[Table/Fig-6]: MRI image of Type III SF.



[Table/Fig-7]: MRI image of Type IV SF.



[Table/Fig-8]: MRI image of Type V SF.

DISCUSSION

Symmetrical SF morphology was observed in 89.5% of participants in the present study, closely aligning with the findings of Maslehaty H et al., who reported bilateral mirror-image symmetry in 88.7% of cases using combined CT and MRI modalities. This high degree of bilateral symmetry underscores the value of the contralateral hemisphere as a reference during neurosurgical planning, particularly in cases involving unilateral pathology [7].

The present study identified Type I and Type II fissures as the most common SF morphologies in both hemispheres. In contrast, Aranha KN et al., reported Type IV (narrow SF with herniation) as the most prevalent pattern overall [8]. Furthermore, Hou L et al., demonstrated measurable SF asymmetries, including rightward dominance in vertical SF length and leftward dominance in anterior horizontal SF length in humans [9]. The predominance of Type I morphology on the left and Type II on the right in the current study may reflect underlying morphological correlates of these functional asymmetries, although segmental length measurements were not performed.

Additionally, the cadaveric study by Idowu OE et al., reported consistent leftward dominance in SF length with significant individual variability, which aligns with our observation of predominantly symmetrical SF types [10]. Their findings of a longer left SF may partially explain the higher prevalence of wider (Type I) fissures observed on the left hemisphere in our MRI-based analysis.

Limitation(s)

The present study population was drawn from a single tertiary care centre, which may limit generalisability to other populations. The retrospective design restricted control over imaging parameters and precluded correlation between SF morphology and clinical or surgical outcomes. Additionally, the age range was limited to adults aged 30-60 years, excluding paediatric and elderly groups in whom morphological patterns may differ. Interobserver variability in SF classification was not assessed, which may affect reproducibility.

CONCLUSION(S)

The present study provides a comprehensive MRI based evaluation of SF morphology, demonstrating that Type I and Type II patterns are almost equally distributed across cerebral hemispheres and that symmetrical configurations are highly prevalent. These findings support the utility of standardised SF classification in radiological and neurosurgical practice and highlight the structural consistency of the SF within the Indian population.

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PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Radiodiagnosis, Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India.
2. Resident, Department of Radiodiagnosis, Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India.
3. Assistant Professor, Department of Radiodiagnosis, Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India.
4. Professor, Department of Radiodiagnosis, Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India.
5. Professor and Head, Department of Radiodiagnosis, Sri Manakula Vinayagar Medical College and Hospital, Puducherry, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Sujeeth Mariyappan,
Madagadipet, Puducherry, India.
E-mail: sujeethkm.maruthi@gmail.com

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