Section: Anatomy

JAMP

Original Research Article

A CADAVERIC STUDY ON MORPHOLOGICAL PATTERNS OF POSTCENTRAL SULCUS IN HUMAN BRAINS

Chakraborty Mousumi[1], Hussain Feroz[2], Hazarika Bornali[3], Mitra Satyajit[4]

[1]Corresponding Author, Postgraduate trainee, Department of Anatomy, Gauhati Medical College, Guwahati, Assam, India.
[2]Assistant Professor, Department of Anatomy, Gauhati Medical College, Guwahati, Assam, India.
[3]Associate Professor, Department of Anatomy, Gauhati Medical College, Guwahati, Assam, India.
[4]Professor, Department of Anatomy, Gauhati Medical College, Guwahati, Assam, India.

Received : *25/03/2025*
Received in revised form : *09/05/2025*
Accepted : *28/05/2025*

Keywords:
Postcentral Sulcus, Morphological Patterns, Intraparietal Sulcus, Lateral Sulcus, Functional Neuroanatomy.

Corresponding Author:
Dr. Mousumi Chakraborty
Email: mousumic1997@gmail.com

DOI: 10.47009/jamp.2025.7.3.176

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (3); 915-920

ABSTRACT

Background: The postcentral sulcus (PoCS) along with other cerebral sulci was first depicted by an Italian Anatomist, Julius Casserius in the year 1545 and was accurately portrayed by another Italian Anatomist, Luigi Rolando in the year 1829. It is an important structural landmark and serves as a boundary between the postcentral gyrus and posterior parietal cortex. It plays a crucial role in various cognitive processes. Despite of its significance, the morphological patterns of postcentral sulcus remains underexplored. This study aims to investigate the morphological patterns of postcentral sulcus (PoCS) in association with surrounding sulci and gyri. **Materials and Methods:** A cross-sectional analytical study was conducted on 25 whole brains (50 hemispheres) sourced from embalmed adult human cadavers. The postcentral sulcus was 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:** This study identified various morphological patterns of PoCS in relation to its continuity as well as in relation to the neighbouring sulci like intraparietal sulcus (IPS), lateral fissure (LF), superior longitudinal fissure (SLF) and marginal sulcus, with varying frequencies and distributions across hemispheres. Our findings align with previous research, highlighting the asymmetry and patterning of postcentral sulcus. These results have implications for neurosurgical planning, functional neuroimaging and clinical applications. The study 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 patterns of postcentral sulcus, contributing to our understanding of this important structural landmark. Further study using radiological techniques may validate these findings in living subjects and explore their functional significance further.

INTRODUCTION

The superolateral surface of cerebral hemisphere features a prominent sulcus called the postcentral sulcus (PoCS). It originates in or near the superomedial border of cerebral hemisphere, a little behind the midpoint between the frontal and occipital poles and run downwards and forwards parallel to the central sulcus to end in the posterior ramus of lateral fissure (fissure of Sylvius).[1] The PoCS display notable morphological variability among individuals.[2] Known for its integrative functions, the PoCS plays a crucial role in integration of sensory information from the body, such as touch, pain, temperature, vibration, proprioception and movement.[3] Consequently, understanding the morphology of PoCS holds significance for diagnosis and management of neurodegenerative disorders of cerebral cortex and focal cortical dysplasia in and around PoCS.[4-8]

This study seeks to investigate the morphological patterns of PoCS in relation to its continuity as well as in relation to the neighbouring sulci like intraparietal sulcus (IPS), lateral fissure (LF), superior longitudinal fissure (SLF) and marginal sulcus. These investigations are important for advancing contemporary functional and structural neuroimaging studies.[9-16]

MATERIALS AND METHODS

A cross-sectional analytical study was conducted in 25 whole brains (50 hemispheres), sourced from embalmed adult human cadavers, obtained from Department of Anatomy and Department of Forensic Medicine & Toxicology at Gauhati Medical College and Hospital. Assam, India, spanning from April 2024 to April 2025.These cadavers were either donated for educational purposes or utilized for medico-legal investigations. Identification of PoCS on superolateral and medial surfaces of brain was performed with reference to established landmarks, including central sulcus, posterior ramus of lateral sulcus and IPS on superolateral surface and marginal sulcus on medial surface of brain. The origin and termination of PoCS were meticulously examined using sulcal depth employing 3-D planes (e.g., sagittal, coronal and horizontal planes) during precise dissection. The morphological patterns of PoCS were investigated in relation to its continuity as well as in relation to the neighbouring sulci like IPS, LF, SLF and marginal sulcus. Three observers were involved to mitigate inter-observer variability, and the average findings were considered for inclusion in the results. The statistical analysis was done by using mean and standard deviation and p- value was calculated using t-test.

Table 1: Inclusion and Exclusion Criteria

Sl No.	Inclusion Criteria	Exclusion Criteria
1.	Normal human brains collected from cadavers donated for educational or medico-legal purposes, irrespective of age and gender.	Morphologically damaged brains, brains with pathological lesions and brains subjected to post-mortem manipulation.

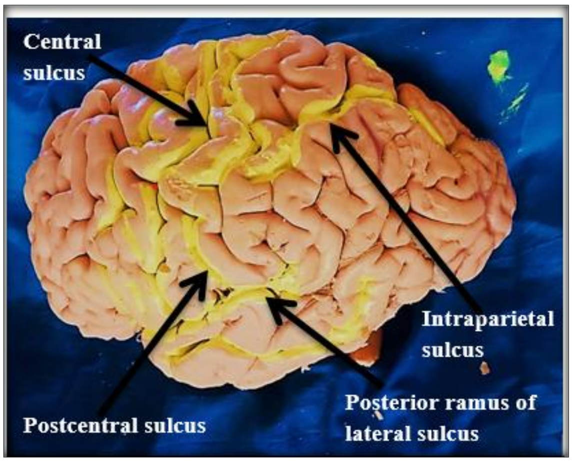

Figure 1: Brain Specimen with anatomical landmark [10, 17]

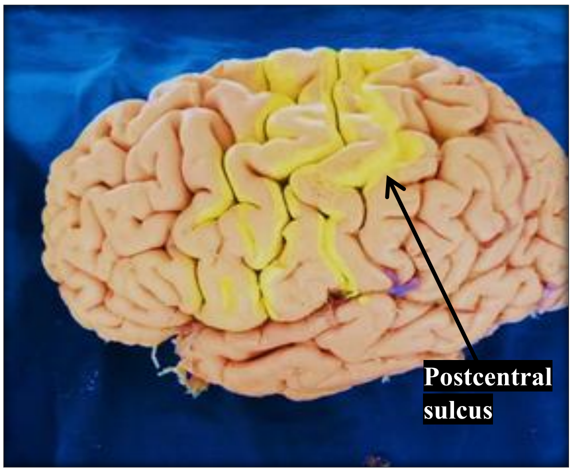

Figure 2: PoCS separated into two segments [10, 17]

Figure 3: Bifurcated superior end of PoCS [10, 17]

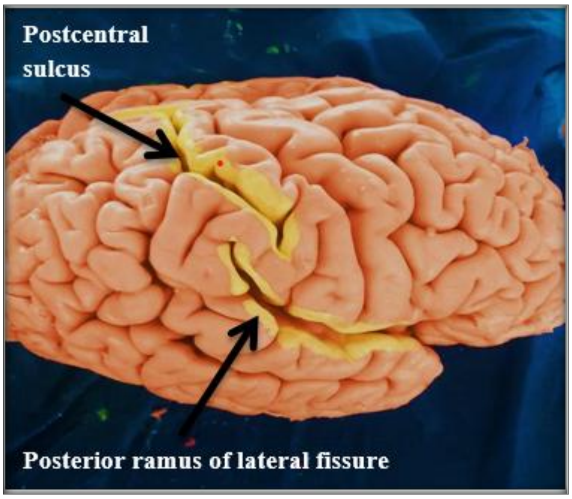

Figure 4: Inferior end of PoCS does not merge with posterior ramus of LF [10, 17]

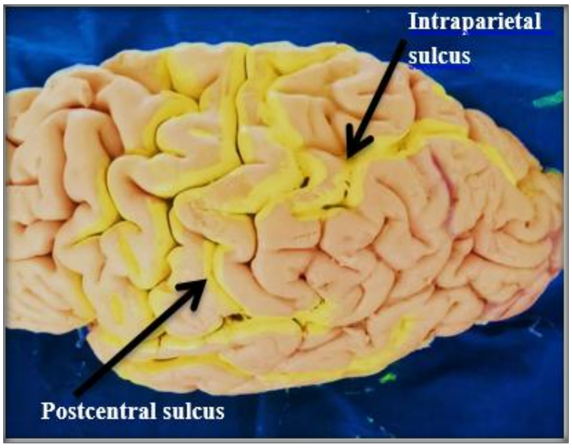

Figure 5: Anterior end of IPS separated from all segments of PoCS by a visible gyrus [10, 17]

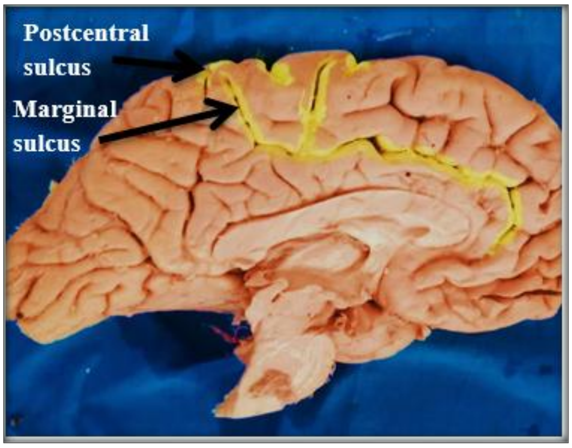

Figure 6: Superior end of PoCS merges with marginal sulcus [10, 17]

RESULTS

In majority of examined cerebral hemispheres, the PoCS was separated into two segments (44%:-48% right, 40% left) or three segments (40%:-12% right, 36% left), but in only 16% cases (20% right, 12% left) it remains continuous.

In approximately 80% cases, the superior end of PoCS terminates on the superolateral surface of cerebral hemispheres. The termination of superior end of PoCS was bifurcated in maximum number of cases (64%:-88% right, 72% left), whereas it was regular without bifurcation in 31% cases (48% right, 28% left). In 37% cases (48% right, 44% left), termination of superior end of PoCS reaches SLF.

In maximum number of cases (66%:-72% right, 60% left), inferior end of PoCS does not merge with posterior ramus of LF whereas in 48% cases (44% right, 52% left), it merges with posterior ramus of LF.

The anterior end of IPS merges with continuous PoCS in 50% cases (60% right, 40% left), merges with inferior segment of PoCS in 32% cases (20% right, 44% left) and merges with middle segment of PoCS in 4% cases (only 8% in left hemisphere). In 64% cases (60% right, 68% left), anterior end of IPS is separated from all the segments of PoCS by a visible gyrus.

In approximately 20% cases, the superior end of PoCS terminates on the medial surface of cerebral hemispheres. In majority of cases (12%:- 52% right, 72% left), superior end of PoCS merges with marginal sulcus whereas in 11% cases (52% right, 56% left), it terminates posterior to marginal sulcus and in 2% cases (3% right, 7% left), it terminates anterior to marginal sulcus.

Table 2: Incidence and Distribution of Postcentral Sulcus (PoCS) Segmentation with Statistical Analysis

Sides Of Cerebral Hemisphere (n)	Continuous n (%)	Two Segments n (%)	Three Segments n (%)	Mean	Standard Deviation (SD)
Right hemisphere (25)	5 (20)	**12 (48)**	3 (12)	0.80	2.43
Left hemisphere (25)	3 (12)	**10 (40)**	9 (36)	**0.88**	**2.47**
Bilateral (50)	8 (16)	**22 (44)**	12 (24)		

Table 3: Incidence and Distribution of patterns formed by Superior End of Postcentral Sulcus (PoCS) on superolateral surface with Statistical Analysis

Sides Of Cerebral Hemisphere (n)	Superior End Is Regular n (%)	Superior End Is Bifurcated n (%)	Superior end reaches SLF n (%)	Mean	Standard Deviation (SD)
Right hemisphere (25)	12 (48)	**22 (88)**	12 (48)	**1.84**	**4.95**
Left hemisphere (25)	7 (28)	**18 (72)**	11 (44)	1.44	4.91
Bilateral (50)	19 (31)	**40 (64)**	23 (37)		

Table 4: Incidence and Distribution of patterns formed by Inferior End of Postcentral Sulcus (PoCS) with Posterior Ramus of Lateral Fissure (LF) with Statistical Analysis

Sides Of Cerebral Hemisphere (n)	PoCS Merges With Posterior Ramus of LF n (%)	PoCS Doesn't Merge With Posterior Ramus of LF n (%)	Mean	Standard Deviation (SD)
Right hemisphere (25)	11 (44)	**18 (72)**	**1.16**	**3.90**
Left hemisphere (25)	13 (52)	**15 (60)**	1.12	3.85
Bilateral (50)	24 (48)	**33 (66)**		

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

Table 5: Incidence and Distribution of patterns formed by Postcentral Sulcus (PoCS) with Anterior End of Intraparietal Sulcus (IPS) with Statistical Analysis

Sides Of Cerebral Hemisphere (n)	IPS Merges With Continuous PoCS n (%)	IPS Merges With Superior Segment Of PoCS n (%)	IPS Merges With Inferior Segment Of PoCS n (%)	IPS Merges With Middle Segment Of PoCS n (%)	IPS Seperated From All Segements Of PoCS By Visible Gyrus n (%)	Mean	Standard Deviation (SD)
Right hemisphere (25)	15 (60)	0	5 (20)	0	**15 (60)**	1.40	3.91
Left hemisphere (25)	10 (40)	5 (20)	11 (44)	2 (8)	**17 (68)**	**1.80**	**3.96**
Bilateral (50)	25 (50)	5 (10)	16 (32)	2 (4)	**32 (64)**		

Table 6: Incidence and Distribution of patterns formed by Postcentral Sulcus (PoCS) with Marginal Sulcus on Medial Surface with Statistical Analysis

Sides Of Cerebral Hemisphere (n)	PoCS Merges With Marginal Sulcus	PoCS Terminates Anterior To Marginal Sulcus	PoCS Terminates Posterior To Marginal Sulcus	Mean	Standard Deviation (SD)
Right hemisphere (25)	**13 (52)**	3 (12)	12 (52)	1.16	5.10
Left hemisphere (25)	**18 (72)**	7 (28)	14 (56)	**1.56**	**5.18**
Bilateral (50)	**31 (12)**	10 (2)	27 (11)		

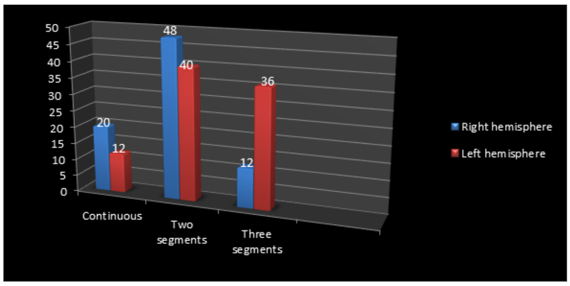

Figure 7: Histogram showing distribution of PoCS segmentation between right and left hemispheres

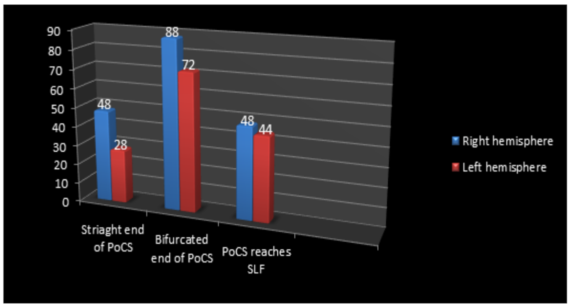

Figure 8: Histogram showing distribution of patterns of termination of superior end of PoCS on superolateral surface between right and left hemispheres

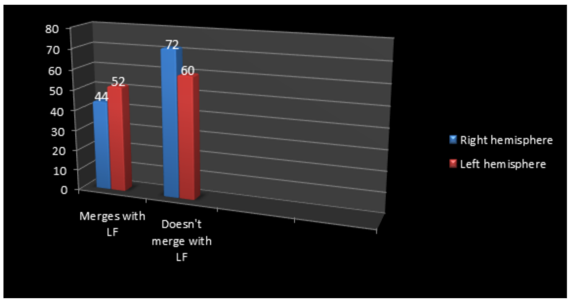

Figure 9: Histogram showing distribution of patterns formed by inferior end of PoCS and posterior ramus of LF between right and left hemispheres

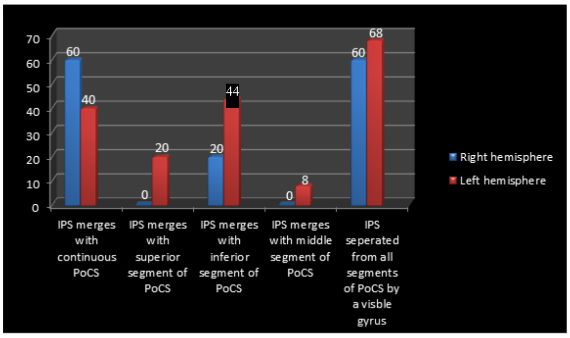

Figure 10: Histogram showing distribution of patterns formed by anterior end of IPS and PoCS between right and left hemispheres

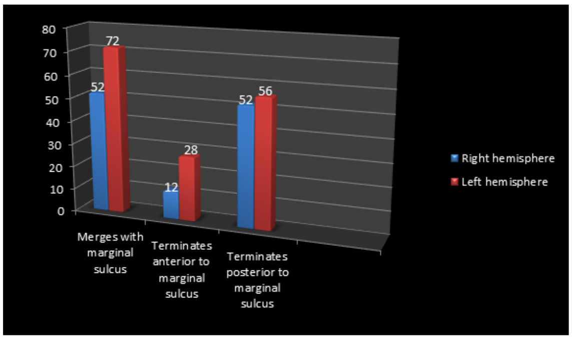

Figure 11: Histogram showing distribution of patterns formed by PoCS and marginal sulcus on medial surface between right and left hemispheres

From statistical analysis of morphological patterns of PoCS, it was found that the left hemisphere was dominant over the right hemisphere on the basis of some parameters like segmentation, patterns formed with anterior part of IPS and patterns formed with marginal sulcus, whereas the right hemisphere was

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

dominant over the left hemisphere on the basis of rest of the parameters like patterns of superior end on superolateral surface and patterns formed with LF. The p values that were calculated by t-test were found to be moderately significant in all morphological patterns of PoCS, except in the pattern formed with marginal sulcus that was insignificant with moderate influence on dependent variables.

DISCUSSION

Our study aimed to investigate the morphological patterns of PoCS of cerebral hemispheres in human cadaveric brains from Assam, India. Our findings shed light on the anatomical importance of this region, along with its implications for neuroanatomical understanding, surgical planning and functional neuroimaging. Our result align with previous research by Lohmann and Cramon et al, who also identified two segments of PoCS in majority of cases (50%), followed by three segments (24%) and only 10% of continuous PoCS. The morphological patterns had also been documented in other studies.[18-20]

Table 7: Comparison of Morphological Patterns of Postcentral Sulcus (PoCS) between Present and Previous Studies

Sl. No.	Parameters of PoCS	Lohmann and Cramon et al (30 specimens) (%)	Regis et al (20 specimes) (%)	Huttner et al (30 specimens) (%)	Present Study (50 specimens) (%)
A)	**Segmentation**				
1)	Continuous PoCS	10		18	16
2)	Two Segments	**58**		**70**	**44**
3)	Three Segments	24		50	24
B)	**Patterns of superior end** Superior				
1)	end is regular		40		31
2)	Superior end is bifurcated		**74**		**64**
3)	Superior end reaches SLF		38		37
C)	**Patterns formed with LF**				
1)	Merges with LF	**50**	42	56	48
2)	Do not merge with LF	42	**50**	**68**	**66**
D)	**Patterns formed with IPS**				
	Merges with continuous PoCS				
1)	Merges with superior segment of PoCS	**48**		50	50
2)	Merges with inferior segment of PoCS	16		18	10
3)	Merges with middle segment of PoCS	36		40	32
	Separated from all segments of PoCS with visible gyrus				
4)		0		2	4
5)		42		**60**	**64**
E)	**Patterns formed with marginal sulcus**				
1)	Merges with marginal sulcus		**30**	**42**	**12**
	Terminates anterior to marginal sulcus				
2)	Terminates posterior to marginal sulcus		22	24	2
3)			26	37	11

Implications of the findings include

1) Neurosurgical planning- The precise knowledge of PoCS morphology is crucial for neurosurgeons planning intervention in parietal lobe and surrounding areas. Identifying the PoCS is crucial to preserve sensory functions during surgery.[13,14]

2) Functional neuroimaging-The segmentation of PoCS over the superolateral surface of brain are related to somatosensory representation of different parts of body. This finding can be supplemented by functional neuroimaging that helps in localising specific brain functions.[7]

3) Clinical applications- Abnormalities in the region surrounding the PoCS have been implicated in various neurodegenerative disorders including epilepsy, Alzheimer's disease, sensory processing disorder and focal cortical dysplasia in and around PoCS. Our study's findings could contribute to the diagnosis, treatment and management of such conditions.[6]

4) Functional processing- The proximity of PoCS to the postcentral gyrus associated with sensory processing underscores its importance in these functions. Insights from our study could inform research and interventions aimed at understanding and treating sensory disorders.[9]

5) Neurodevelopmental disorders- Anomalies in brain development, including variations in sulcal patterns, have been implicated in autism spectrum disorder and ADHD.[12] Understanding the normal and variant anatomy of PoCS could contribute to early detection and intervention in such disorders.

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

6) Neurorehabilitation- Knowledge of PoCS anatomy can aid in the development of targeted rehabilitation strategies for undergoing rehabilitation following stroke or traumatic brain injury.[8]

Limitation(s)

1) Sample characteristics: Our study exclusively utilized cadaveric adult human brains. 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 differentially from the in vivo state.

2) Exclusion of pathological brains: Our study excluded morphologically damaged brains, brains with pathological lesions and brains subjected to post-mortem manipulation. While these exclusion criteria aimed to ensure the integrity of the specimens, it may have introduced selection bias and limited representativeness of our sample.

3) Methodological constraints: Identification of PoCS and its relation with surrounding sulci relied on manual dissection and observation, introducing potential for inter-observer variability. Despite efforts to mitigate this variability by involving three observers and averaging their findings, subjective judgements may have influenced the results.

4) Inability to assess functional correlates: Our study focused on morphological patterns of PoCS 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 morphological patterns of PoCS.

5) Lack of longitudinal data: Our study design was cross-sectional, providing a snapshot of PoCS morphology at a single point of time. Longitudinal studies tracking changes in PoCS 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.

CONCLUSION

This study provides valuable insights into the intricate morphological patterns of PoCS within the parietal lobe of human cadaveric brains. Our findings align with previous research and contribute to comprehensive understanding of this anatomical feature. However, further investigations involving living subjects, coupled with fMRI analyses 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 this sulcal structure and their potential role in neuroanatomical variability and cognitive function.

REFERENCES

1. Susan Standring, Gray's Anatomy, The anatomical basis of clinical practice: Cerebral hemispheres.41st edition. Elsevier; 2016; 376-372
2. Amiez, C., Kostopoulos, P., Champod, A. S., & Petrides, M. Local morphology predicts functional organization of the dorsal premotor region in the human brain. The Journal of Neuroscience; 2006; 26(10): 2724-2731.
3. Baumann, M. A., Fluet, M. C., & Scherberger, H. Context-specific grasp movement representation in the macaque anterior intraparietal area. The Journal of Neuroscience; 2009; 29(20): 6436-6448.
4. Binkofski, F., Dohle, C., Posse, S., Stephan, K. M., Hefter, H., Seitz, R. J., & Freund, H. J. Human anterior intraparietal area subserves prehension A combined lesion and functional MRI activation study. Neurology; 1998; 50(5); 1253-1259.
5. Binkofski, F., Buccino, G., Posse, S., Seitz, R. J., Rizzolatti, G., & Freund, H. J. A fronto-parietal circuit for object manipulation in man: evidence from an fMRI-study. European Journal of Neuroscience; 1999; 11(9): 3276-3286.
6. Blatow, M., Nennig, E., Durst, A., Sartor, K., & Stippich, C. fMRI reflects functional connectivity of human somatosensory cortex. Neuroimage; 2007; 37(3): 927-936.
7. Boling, W., Olivier, A., Bittar, R. G., & Reutens, D. Localization of hand motor activation in Broca's pli de passage moyen. Journal of Neurosurgery; 1999; 91(6): 903-910.
8. Boling, W., Reutens, D. C., & Olivier, A. Functional topography of the low postcentral area. Journal of Neurosurgery; 2002; 97(2): 388-395.
9. Chiavaras, M. M., & Petrides, M. Orbitofrontal sulci of the human and macaque monkey brain. Journal of Comparative Neurology; 2002; 422(1): 35-54.
10. Collins, D. L., Neelin, P., Peters, T. M., & Evans, A. C. Automatic 3D intersubject registration of MR volumetric data in standardized Talairach space. Journal of Computer Assisted Tomography; 1997; 18(2): 192-205.
11. Connolly, C. J. External morphology of the primate brain. Springfield: Charles C Thomas; 1950; 20(6): 200-201.
12. Cunningham, D.J. Contribution to the surface anatomy of the cerebral hemispheres by D. J. C., with a chapter upon cranio-cerebral topography by Victory Horsley. Dublin: Royal Irish Academy; 1892; 16(4); 130-134.
13. Duvernoy, H. M., Cabanis, E. A., & Bourgouin, P. The human brain: surface, three dimensional sectional anatomy and MRI. Wien: Springer-Verlag; 1991; 16(2); 180-182.
14. Eberstaller, O. Das Stirnhirn. Cellular structure of the human cerebral cortex. Basel: Karger Medical and Scientific Publishers; 1890; 18(5); 380-384.
15. Germann, J., Robbins, S., Halsband, U., & Petrides, M. Precentral sulcal complex of the human brain: morphology and statistical probability maps. Journal of Comparative Neurology; 2005; 493(3): 334-356.
16. Eickhoff, S. B., Amunts, K., Mohlberg, H., & Zilles, K. The human parietal operculum II. Stereotaxic maps and correlation with functional imaging results. Cerebral Cortex; 2006; 16(2): 268-279.
17. Smith, G. E.A new topographical survey of the human cerebral cortex, being an account of the distribution of the anatomically distinct cortical areas and their relationship to the cerebral sulci. Journal of Anatomy and Physiology; 1907; 41(4): 237-254.
18. Fabri, M., Polonara, G., Salvolini, U., & Manzoni, T.Bilateral cortical representation of the trunk midline in human first somatic sensory area. Human Brain Mapping; 2005; 25(3): 287-296.
19. Ferretti, A., Del Gratta, C., Babiloni, C., Caulo, M., Arienzo, D., Tartaro, A., Rossini, P. M., & Luca Romani, G.Functional topography of the secondary somatosensory cortex for nonpainful and painful stimulation of median and tibial nerve: an fMRI study. Neuroimage; 2004; 23(3): 1217-1225.
20. Frey, S. H., Vinton, D., Norlund, R., & Grafton, S. T.Cortical topography of human anterior intraparietal cortex active during visually guided grasping. Cognitive Brain Research; 2005; 23(2): 397-405.

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