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Original Research Article

Revisiting almost forgotten two ends of the central sulcus of cerebral hemisphere in brains of cadavers

Dharmendra Kumar[1,*], Manisha B Sinha[1], Madhusmita Panda[2], Chinmayi Mohapatra[2]

[1]*Dept. of Anatomy, All India Institute of Medical Sciences, Raipur, Chhattisgarh, India*
[2]*S.C.B. Medical College and Hospital, Cuttack, Odisha*

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ABSTRACT

Objective: The central sulcus also known as Rolandic Fissure separates the sensory cortex in front from motor cortex behind. The central sulcus starts in or near the superomedial border of the cerebral hemisphere, and ends usually a little above the posterior ramus of the lateral sulcus. The central sulcus is the only sulcus that divides the brain at its superior surface. The objective of the present study was to analyse the various types of the central sulcus of cerebral hemisphere with respect to its two ends in the cadavers.

Materials and Methods: A total of 44 cadaveric brains (88 cerebral hemispheres) were studied. The variations at upper end of the central sulcus with respect to the superomedial border of the hemisphere and at its lower end with respect to the posterior ramus of the Sylvian fissure were noted.

Results: At the upper end, we found three types of central sulcus – type 1= 68% (those cutting the border and extending on the medial surface), type 2= 23% (those just reaching the border but not reaching the medial surface) and type 3 =9% (those falling short of the border). At the lower end of the fissure, we observed two types of the central sulcus – type 2=83% (those falling short of the posterior ramus of the Sylvian fissure) and type 1=17% (those reaching the posterior ramus of the Sylvian fissure).

Conclusion: The variability in the morphology of the cortical gyri and sulci including size, shape and spatial pattern has been previously reported. Such variability raises methodological issues for functional brain mapping1 as well as for lesion localization in neurosurgical planning. This finding will be useful to anatomists, neurosurgeons, radiologists etc. Compared to Chinese population, the percentage of type 2 of the upper end was almost half in our study which represents central India population. Further clinical research is required by radiological examination of the two ends of the central sulcus to determine any association with functional anatomy as well as any correlation with various diseases of the brain.

1. Introduction

The central sulcus (CS) also known as central fissure/fissura centralis/the fissure of Rolando/Rolandic fissure[1] named after Luigo Rolando (Italian anatomist), is a type of limiting sulcus (functionally) separating agranular motor cortex in front from granular sensory cortex behind. The Central Sulcus is the only sulcus that divides the brain at its superior surface.[2] Thus, it is the only sulcus that lies in the coronal plane that runs from the lateral part of the brain to the midline.

The central sulcus is usually described as starting in or near the superomedial border of the cerebral hemisphere, a little behind the midpoint between frontal and occipital poles and runs sinuously, resembling a lengthened letter S, downwards and forwards, and ending usually a little above the posterior ramus of the lateral sulcus.[3] However there are many variations of the two ends of the central sulcus, which are not emphasised upon in literature. The variation in size, shape and configuration of the cortical sulci and gyri had been well documented in different studies. Such variability raises methodological issues for functional brain mapping as well as for lesion localization in neurosurgical planning. Difficulties

* *Corresponding author*.
E-mail address: drdkumar.2020@gmail.com (D. Kumar).

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in differentiating normal from abnormal morphological variations affect the detection of subtle dysmorphology associated with neurological or psychiatric conditions, e.g., neurodevelopmental impairments, schizophreniaor malformation of cortical development.

The morphometric features of sulcus can also be used for somatotropic localization.[4] The identification of precise location, configuration and morphometry of central sulcus is of great importance when surgery in the vicinity of motor cortex is planned. The aim of this study was to assess its variations in superior or medial end near the interhemispheric fissure (IHF) and inferior or lateral end near the Sylvian fissure. This type of variations of the central sulcus has been mentioned by Prof. Cunningham[1], Chi & Chang,[5] Retzius,[6] Ribas et al.,[7] Yucel et al.,[8] Ebeling et al.,[9] Choi et al.[10] etc, still many anatomists, radiologists are not familiar with it.

2. Materials and Methods

The present study was conducted on 88 cerebral hemispheres obtained from the Department of Anatomy as well as from the morgue of Department of F.M.T. of SCBMCH, Cuttack and Department of Anatomy, All India Institutes of Medical Sciences, Raipur, Chhattisgarh.

We examined the two extremities of the Rolandic Fissure, namely the upper end and the lower end. It is important to note that the upper end lies near the superomedial border of the cerebral hemisphere or the median longitudinal fissure while the lower end usually lies near the lateral sulcus. We found three types of superior end with respect to superomedial border and two types of inferior end with respect to Sylvian fissure. The variations were recorded and photographed.

The superior end of the central sulcus at the superomedial border (SMB) was found to be of three types;

Type 1: Those cutting the border and reaching the medial surface

Type 2: Those just reaching the border

Type 3: Those falling short of the border

The inferior end of the central sulcus was found to be of two types;

Type 1: Those connected to the lateral sulcus and extending into it

Type 2: Those ending a little above it

3. Observations and Results

At the upper end of the central sulcus of the 44 right cerebral hemispheres, Type 1, Type 2, Type 3 was found in 28, 11 and 5 hemispheres respectively while at the upper end of central sulcus of the 44 left cerebral hemispheres, Type 1, Type 2, Type 3 was found in 32, 9 and 3 hemispheres respectively.

Thus, in total 88 cerebral hemispheres, Type 1 of the upper end was seen in 60 hemispheres (68%), Type 2 was seen in 20 hemispheres (23%) while Type 3 was seen in 8 hemispheres (9%).

At the lower end of the central sulcus of 44 right cerebral hemispheres, Type 1 and Type 2 was found in 7 and 37 hemispheres respectively while in 44 left cerebral hemispheres, Type 1 and Type 2 was found in 8 and 36 hemispheres respectively.

Thus, in total 88 cerebral hemispheres, Type 1 of the lower end was seen in 15 hemispheres (17%) and Type 2 was seen in 73 hemispheres (83%).

4. Discussion

The study of anatomy has undergone a vast amount of changes from the time of Praxagoras of Cos (c300 BC) and Erasistratus of Chios (c260 BC) who named gyri as coils[11] as well as Rolando (1773-1831) of university of Turin, who called them as enteroid process. Giacomo Berengario De Carpi in the first anatomy textbook ever published[12] in 1523 “Isagoge Breves” described brain as intestinal loops (“venter superius”).

Chi et al.[13] have mentioned that the central sulcus first appears during the 20th week of gestation, but sometimes it is seen as early as the 17th week on the right cerebral hemisphere. The drawings presented with the text in Chi et al. shows that the sulcus is still short of the midline at the end of the 31st week and it reaches the interhemispheric fissure between the 32nd and 35th weeks.

Although Paul Broca[1,14] was the first anatomist to describe the superior and inferior ends of central sulcus in 1878, it was Prof. Cunningham,[1] who in 1882 described in detail about the variations of the Rolandic fissure with respect to its two ends. Ono et al.[15] have described the central sulcus in detail recently, utilizing 16 criteria. Although the variations related to the central sulcus has been known since nineteenth century (almost 20 yrs before the publication of the “bible of anatomy”- Grays anatomy), still the variations at its two ends remain unknown to many learned anatomists and academicians.

In 1892, Prof. Cunningham[1] examined 52 cerebral hemisphere of Irish population. He found that at the superior end, the Type 1 was most common and it was found in 60% of the specimens examined while Type 3 was the least common, found in only 19%. The findings of our study are almost similar.

Retzius[6] noted that the discontinuity of the central sulcus was present in only 1 % of the specimens of Swedish population examined by him. However, the number of specimens studied has not been mentioned. The central sulcus was continuous in our study in 100% of the specimens studied. He reported that the CS was in the IHF in 64 %, was combined or at the close proximity to the IHF in 16 %, and was separate in 20 % of the specimens. He found that the CS was combined with the lateral sulcus in 17 % of the specimens (Type1).

Table 1: Distribution of the three types of upper end of the central sulcus seen at the SMB of the hemispheres

Type of upper end	Right hemisphere	Left hemisphere	Total	Percentage (%)
Type 1	28	32	60	68
Type 2	11	9	20	23
Type 3	5	3	8	9
Total	44	44	88	100

Table 2: Distribution of the two types of lower end of the central sulcus seen near the lateral sulcus

Type of lower end	Right hemisphere	Left hemisphere	Total	Percentage (%)
Type 1	7	8	15	17
Type 2	37	36	73	83
Total	44	44	88	100

Table 3: Distribution of the 3 types of the upper end of the Rolandic sulcus in different population studied

Authors (years)	Population	Upper End		
		Type 1	Type 2	Type 3
Prof. Cunningham (1892)	European-Ireland (52 hemispheres)	60%	21%	19%
Retzius (1896)	Swedish (NA)	64	16	20
Chi & chung chang (1941)	Chinese (100 hemispheres)	52	40	8
Ribas et al. (2006)	South American-Brazilian (32 hemispheres)	100	0	0
Present Study (2017)	Indian (88 hemispheres	68	23	9

Table 4: Distribution of the 3 types of the lower end of the Rolandic sulcus in different population studied

Authors	Population	Lower End	
		Type 1	Type 2
Chi & Chung Chang (1941)	Chinese (100 hemisphere)	16%	84%
Ebeling et al (1995)	European-Swiss (20 MRI & 62 cadaveric hemispheres)	13% (5) 15% (9)	73% 85%
Ribas et al (2006)	S.American- Brazilian (30 hemispheres)	17% (5)	83% (25)
Yucel Gonul et al (2014)	Middle East- Turkish (100 hemispheres)	28%	72%
Present Study (2018)	Indian (88 hemispheres)	17% (15)	83% (73)

Chi and Chung Chang[5] studied brains of Chinese population and found that the central sulcus cuts the supero-medial border at an average distance of 158.38 mm. from the frontal pole and 129.17 mm. from the occipital pole, with an average of 14.61 mm. behind the mid-point of supero-medial border of the brain. With respect to the relation of the upper end of the central sulcus with the supero-medial border, the 3 types obtained by them were as follows: Type I = 52%, Type 2 = 40%, Type 3 = 8%. They found higher percentage of Type 2 compared to our study which may be due to different number of the specimens as well as different population examined. The distance from the lower end of the central sulcus to the Sylvian fissure was found to be 6.4 mm in average. The lower end of the central sulcus joined the Sylvian fissure in nine cases (four right, five left) and in another seven cases (five left, two right) it almost touched the Sylvian fissure.

Ribas et al.[7] studied 32 cerebral hemisphere (7 females and 9 males of 36-85 yrs age) and observed that the central sulcus was a continuous sulcus not connected to any other sulci anteriorly or posteriorly. Its superior extremity was situated inside IHF in all studied specimens i.e. all specimens had type 1 of the superior end. In our study, we found type 1 of the upper end in 60%. The inferior extremity of the CS, which was identified in all cases, was superior to Sylvian fissure in 25 specimens (83%) and was located inside the Sylvian fissure in 5 (17%) out of the 30 specimens studied regarding this observation, with an average distance of 0.54 ± 0.62 cm superior to Sylvian fissure. They have not observed any significant sexual dimorphism at the two ends of the CS.

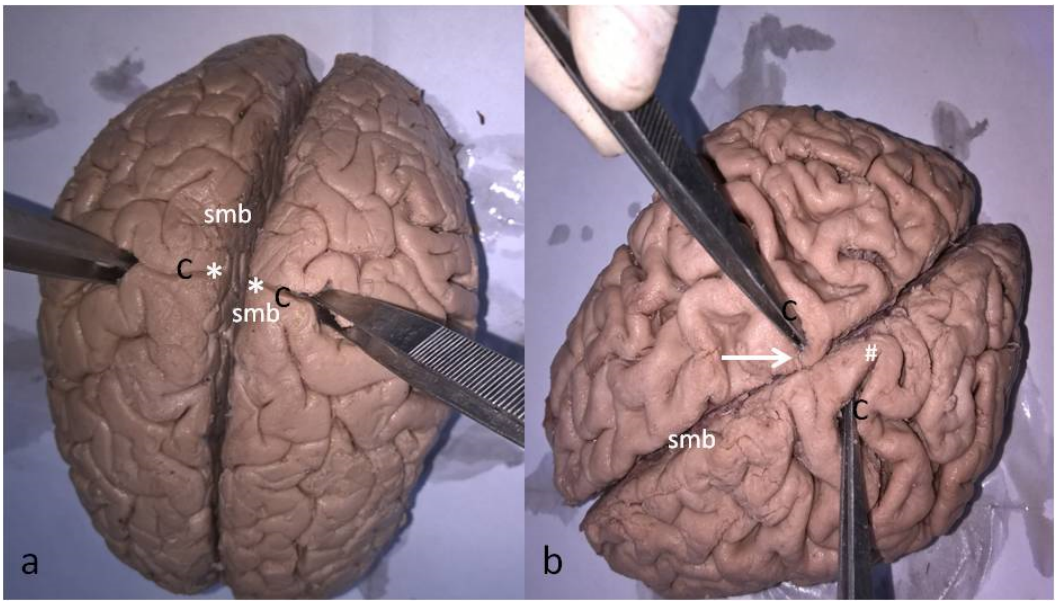

Fig. 1: The types of upper ends of the central sulcus of Rolando (a) *= type 1) (b) → = type and # = type 3, smb= superomedial border, c= central sulcus

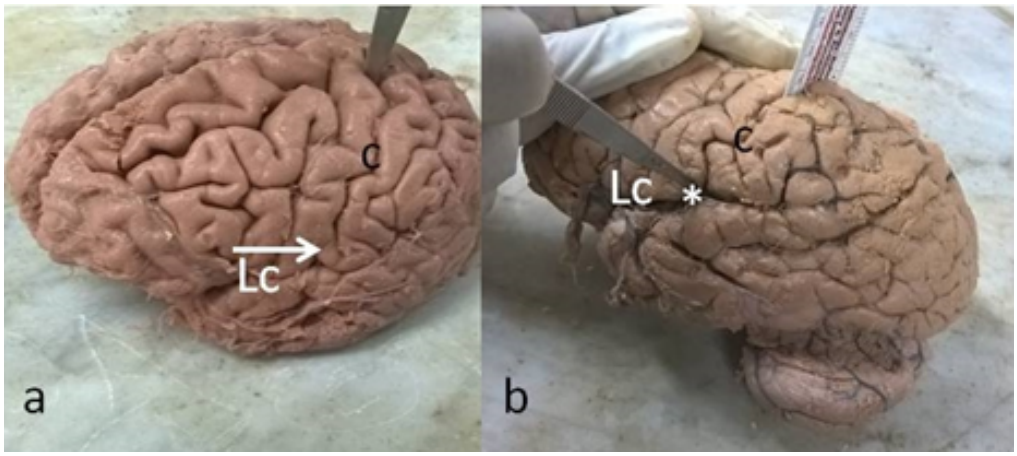

Fig. 2: The two types of the lower end of the central sulcus of Rolando (a) → = type 2, (b)* = type 1, C = central sulcus, LC = lateral sulcus

Ebeling et al.[9] studied 62 cadaveric hemispheres as well as 20 MRI of the brain of Swiss population and found that at the lower end of the central sulcus, type 2 was more common than type 1 in both type of specimens used. The results were slightly lower in MRI study, however it was obvious considering the lower number of specimens used. The findings of our study (type 2=83% and type 1=17%) were almost similar. The ratios obtained by Yucel[13] et al. in the 100 cerebral hemisphere of Turkish population, however, were slightly lower than our study.

The types of upper end of the central sulcus found in the present study (type 1 - 68%, type 2 - 23%, type 3 - 9%) was similar to the findings of Cunningham,[1] Chi and Chang[5] and Retzius[6] while the types of lower end of the central sulcus was similar to findings of Chi and Chang,[5] Ebeling et al.[9] and Ribas et al.[7]

5. Conclusion

The important variations of sulci and gyri provide a natural topographic partition of the cortical anatomy. The variability in the morphology of the cortical sulci and gyri including size, shape and spatial pattern is quite common. We found that the most common type of the CS with respect to the superior end was Type 1 (i.e. CS cutting the border and extending on the medial surface). The most common type of the CS with respect to the inferior end was Type 2

(i.e. C.S. falling short of the posterior rami of the Sylvian fissure). Compared to Chinese population, the percentage of Type 2 of the upper end was almost half in our study which represents central India population. Further clinical research is required by radiological examination of the two ends of the central sulcus to determine any association with functional anatomy as well as any correlation with various diseases of the brain. This finding will be useful to anatomists, neurosurgeons, radiologists etc. Further study is required with a larger sample size to fully ascertain the findings of this study.

6. Conflict of Interest

None.

7. Source of Funding

None.

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Author biography

Dharmendra Kumar Senior Resident

Manisha B Sinha Associate Professor

Madhusmita Panda Associate Professor

Chinmayi Mohapatra Professor

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