

Morphometry of the Central Sulcus in the Brain of Uttar Pradesh Region

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Abstract

Background: Central sulcus is an important structural landmark of the cerebral hemisphere as it is located between the primary motor and the primary somatic sensory cortex. Variations in the morphology of the central sulcus are seen with respect to the length and depth of the central sulcus. This study was done to establish a normal standard in length and depth of central sulcus in the population of Uttar Pradesh region.

Materials and Methods: An analytical cross-sectional study was conducted in 34 brains taken from the anatomy department of Rohilkhand Medical College, Bareilly, Uttar Pradesh. Morphology of the central sulcus was studied with regards to its dimension and contour.

Result: The mean length and depth of the central sulcus was found and compared with other similar studies on a different population.

Conclusion: Knowledge of morphometry of central sulcus is not only important during neurosurgery of brain but also holds tremendous significance in diagnosis and management of diseases of the cerebral cortex.

Key words: Central sulcus, Cerebral hemisphere, Motor cortex, Somatic sensory cortex

INTRODUCTION

The highest level of nervous function resides in the cerebral cortex. It contains the primary sensory and motor areas, as well as multiple association areas. Cerebral cortex which is the primary storehouse for memory also controls the function of lower brain centers. Each area of the cerebral cortex receives specific inputs, which helps in evoking response in a specific part of the body. The surfaces of the cerebral hemisphere are molded into a number of gyri separated by sulci. These sulci and gyri provide a natural topographic partition in the cerebral cortex, which lie on the outer surface of the cerebral hemispheres. The study of the shape, size, and configuration of the sulci has been a subject of interest as many functional zones runs along

the bed of the major or minor sulci. The central sulcus is one of the most important structural landmarks of the cerebral hemisphere as it separates the primary motor from the primary somatic sensory cortex. The study of the central sulcus using post-mortem samples was undertaken in the past by many workers including Broca,¹ Campbell,² Cunningham,³ and White. *et al.*,⁴. The central sulcus or the fissure of Rolando extends across the lateral convex surface of the cerebral hemisphere interrupting the general longitudinal course of the gyri and sulci. The central sulcus begins at the superomedial border near the vertex or the highest point of the hemisphere, somewhat behind the midpoint of the longitudinal fissure. It passes outward, downward, and forward to end near the middle of the fissure of sylvius, the posterior limb of which it sometimes joins. Like most other sulci and gyri, the central sulcus also shows marked variation in size, shape, and configuration.⁵ Typically a central sulcus is divided into three parts by two bends, the upper third facing downward and backward, middle third downward and forward and the lower third vertically downward.³ Depth of the central sulcus is approximately two cm except near its two extremities where it becomes shallower. The depth

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however may vary with age, manual skill and handedness. The right-handed person has a slightly deeper central sulcus in the left cerebral hemisphere as compared to the right hemisphere.⁵ During neurosurgical resection it's important to plan out the neurosurgical approach. This needs a sound knowledge of the location, configuration, and morphometry of the central sulci to avoid any damage to the primary motor cortex which forms its anterior wall. Some degenerative diseases may also affect the cerebral cortex, e.g., Alzheimer's disease which is the commonest cause of dementia in elderly.⁶ The aim of the study was to put more light to the morphometry of the central sulcus, with respect to the length and the depth, in the brain of Uttar Pradesh region.

MATERIALS AND METHODS

The current study was done on post-mortem cerebral hemispheres obtained from the Museum of the anatomy department, from Rohilkhand Medical College, Bareilly. Total of 18 brains were obtained. The morphometric measurement was done on both the cerebral hemispheres. As two of the cerebral hemispheres were damaged, a total of 34 specimens were studied. The meninges were carefully stripped of from the superolateral surface avoiding tearing of the cerebral cortex by the larger blood vessels lying at the bottom of the sulcus. The length of the sulci was measured in millimetres by following the curves of the sulci by a thin wire shown in Figure 1. The depth of the sulci was measured by placing vertically a calibrated scale in the sulci at different locations shown in Figure 2.

RESULTS

Our study which was done on the central sulcus in the brain of samples obtained from Uttar Pradesh region measured the length and depth of the central sulcus. Table 1 and Graph 1 show the length of the central sulcus found in the right hemisphere and left hemisphere. Table 2 compared the mean length of the central sulcus in the right hemisphere which was found to be 94.75 mm with that in the left hemisphere where it measured 96.06 mm ($N = 17$, standard deviation [SD] = 7.73). The conclusion derived was that the length in the left hemisphere was more than that in the right hemisphere. The P value was however found to be insignificant at 0.6242. Table 3 shows the depth of the central sulcus in both the hemisphere. The average maximum depth on the right side was found to be 18.06 mm and on the left side 18.41 mm. The average minimum depth found was 4.88 mm on the right side and 5.47 mm on the left side. The average depth thus measured on the right side was 11.52 mm ($N = 17$, SD = 1.64) and on the left side 12.05 mm ($N = 17$, SD = 1.62). Table 4

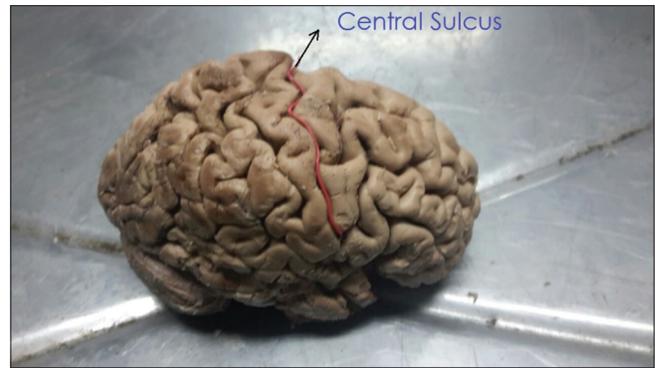
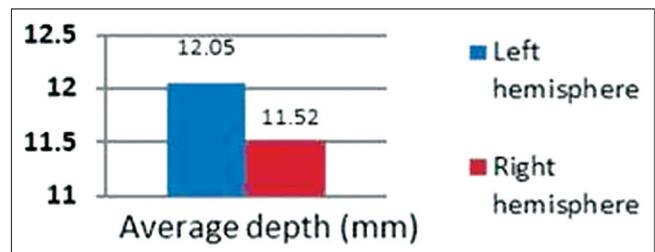


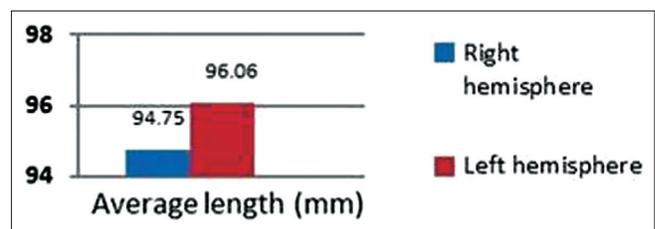
Figure 1: Central sulcus



Figure 2: Central sulcus depth being measured



Graph 1: Average depth



Graph 2: Average length

and Graph 2 compared the depth of the central sulcus in both the hemispheres. The depth was found to be more in the left hemisphere compared to the right hemisphere. The P value of the depth was insignificant at 0.3526. Table 5 shows a comparative analysis of both the length and depth

of the central sulcus. In our study on the brains of Uttar Pradesh region, both the length and the breadth of the central sulcus were found to be more in the left hemisphere.

DISCUSSION

Human central sulcus divides the frontal and parietal lobe. Its anterior wall is formed by primary motor

cortex (Brodmann's area 4) and posterior wall by major portion of primary somatic sensory cortex (Brodmann's area 3). The study of the central sulcus using post-mortem samples have been a subject of interest for many workers in the past. Of all the sulci present in the cerebral hemisphere the central sulcus is the most suited for the study of morphometry as it develops as early as the 20th week of fetal life,⁷ has a more or less constant macroscopic features and very predictably divides two very significant Brodmann's area.^{4,5} This has led to a detailed analysis of the various aspects of central sulcus by many researchers. Blanton *et al.*,⁸ worked on the normal and abnormal sulcal development while Lohmann *et al.*⁹ worked on genetic control over the sulcal shape. Amunts *et al.*¹⁰ demonstrated the structure function relationship in the primary sensorimotor cortex. He also worked on the effect of handedness on central sulcus morphology. Boling *et al.*¹¹ worked on the potential of using sulcal feature for somatotopic localization. The drawback of some of these studies were that since a lot was based on observer's judgment the ability of investigators to provide quantitative markers to recognize landmarks in the central sulcus was limited. One well-known landmark "pli di passage frontoparietal moyen" was however provided by Broca. This appeared as an elevation in the floor of the mid part of the central sulcus. Later studies by White *et al.*,⁴ showed that it corresponded to the somatotopic hand area.

Crossman¹² postulated that the central sulcus ran downward and forward for 8-10 cm before ending a little above the posterior rami of the lateral sulcus. According to Brown and Bottjer¹³ length of central sulcus was >80 mm while Sun *et al.*,¹⁴ estimated it to be 93.28 mm on the left side and

Table 1: Length of the central sulcus

Sample no	Right cerebral hemisphere (mm)	Left cerebral hemisphere (mm)
1	99	96
2	80	91
3	100	107
4	96	95
5	95	97
6	108	113
7	102	92
8	84	82
9	89	102
10	92	94
11	85	86
12	105	104
13	91	95
14	95	90
15	92	90
16	99	98
17	99	101

Table 2: Statistical analysis of length of the central sulcus

Side of cerebral hemisphere	N	Mean	SD	P value
Right hemisphere	17	94.75	7.53	0.6242
Left hemisphere	17	96.06	7.73	

SD: Standard deviation

Table 3: Depth of the central sulcus

Sample no.	Right hemisphere			Left hemisphere		
	Maximum depth (mm)	Minimum depth (mm)	Average depth (mm)	Maximum depth (mm)	Minimum depth (mm)	Average depth (mm)
1	15	6	10.5	17	7	12
2	22	4	13	21	6	13.5
3	14	5	9.5	15	4	9.5
4	18	4	11	21	6	13.5
5	17	3	10	17	4	10.5
6	21	8	14.5	21	9	15
7	16	4	10	19	5	12
8	18	5	11.5	18	13	11.5
9	19	3	11	20	5	12.5
10	18	5	11.5	17	4	10.5
11	17	3	10	18	5	11.5
12	17	5	11	18	6	13
13	18	4	12	18	5	11.5
14	18	3	10.5	15	5	10
15	17	6	11.5	17	4	10.5
16	21	5	13	23	7	15
17	21	10	15.5	18	8	13

Table 4: Statistical analysis of depth of the central sulcus

Side of cerebral hemisphere	N	Mean	SD	P value
Right hemisphere	17	11.52	1.64	0.3526
Left hemisphere	17	12.05	1.62	

SD: Standard deviation

Table 5: Comparison of the length and depth of the central sulcus in both the cerebral hemisphere

Side of cerebral hemisphere	Average length of central sulcus	Depth of central sulcus		
		Maximum	Minimum	Average
Right hemisphere	94.75	18.06	4.88	11.5
Left hemisphere	96.06	18.41	5.47	12.05

84.59 mm on the right side. Kline *et al.*,¹⁵ stated it to be 70-125 mm in autopsied body, average being 94 mm. In our study, which was done on the central sulcus in the brain of samples obtained from Uttar Pradesh region, the average length of the central sulcus found in the right hemisphere was 94.7 mm and on the left hemisphere 96.06 mm. This was in accordance to the findings of studies done on length of central sulcus by Crossman¹² and Brown and Bottjer,¹³ Sun *et al.*¹⁴ and Kline *et al.*¹⁵ Cykowski *et al.*¹⁶ stated that the average maximum depth of the central sulcus on the left side was 16.6 cm while on right side was 16.4 mm. In our study, the average maximum depth was slightly higher being 18.06 mm on the right side and 18.41 cm on a left side.

CONCLUSION

As sulci and gyri are the natural routes to deep brain structure a knowledge of morphometry of the sulci was essential for the surgical planning. It also holds great significance in diagnosis and management of diseases of the cerebral cortex, e.g., in Alzheimer's disease there is

a marked decrease in sulcal depth. Sulcal morphometric features can also be used for somatotopic localization.

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