Original Article

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Morphological Study of the Central Sulcus in Formalin Fixed Human Brain

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Abstract

Central sulcus is very crucial regarding identification of other sulci on the superolateral surface of the cerebral hemisphere of human brain. Surprisingly, cortical sulci and gyri attracted little attention until the 19th century, when clinical neurology, neuropathology and comparative anatomy start to unveil the complexity and functional significance of the cortical mantle. The central sulcus is of special importance because it separates the main motor and sensory areas of the cerebral cortex. Central sulcus is one of the important sulcus and is often difficult to identify. It begins superiorly on the medial surface approximately midway between the frontal and occipital poles and crossing the superomedial border, extends antero-inferiorly to end just superior to the posterior ramus of the lateral sulcus, 2-3 cm posterior to the origin of the lateral sulcus. Contrary to this usual finding we can say from the present study that central sulcus is continues one and is shifted more posteriorly i.e. behind the 50% area from frontal pole when measured at superomedial border of cerebral hemisphere. Central sulcus may not always cut the superomedial border and may not always be arched by prominent arched gyrus at the posterior ramus of the lateral sulcus.

Keywords: Central Sulcus; Posterior Ramus; Lateral Sulcus; Brain.

Introduction

The surface of the cerebral hemisphere shows a complex pattern of convolutions, or gyri, which are separated by furrows of varying depth known as fissures, or sulci. Some of these are consistently located. They partly provide the basis for division of the hemisphere into lobes. On the superolateral cerebral surface two prominent furrows, the lateral (Sylvian) fissure and the central sulcus, are the main features that determine its surface divisions. The central sulcus is the boundary between the frontal and parietal lobes. It starts in or near the superomedial border of the hemisphere, a little behind the midpoint between the frontal and occipital poles. It runs sinuously downwards and forwards for about 8-10 cm which is always limited by an arched gyrus. Its general direction makes an angle of about 70^0 with the median plane. It demarcates the primary motor and somatosensory areas of the cortex, located in the precentral and postcentral gyri, respectively [1].

The superolateral surface of human fetal cerebral hemispheres show the changes in size, profile, and the emerging pattern of cerebral sulci with increasing maturation. By the 6^{th} month the central, precentral, postcentral, superior temporal, intraparietal and parieto-occipital sulci are all clearly visible. In the subsequent stages all the remaining principal and subsidiary sulci rapidly appear and by 40^{th} week all the features which characterize the adult hemisphere in terms of surface topography are present in miniature. The central, precentral and postcentral sulci appear, each in two parts, upper and lower, which usually coalesce shortly afterwards, although they may remain discontinuous [1].

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There are great individual variations in the details of the sulci and gyri, so attention should be given mainly to the major sulci and gyri. According to Cunningham's manual, central sulcus is one of the important sulcus and is often difficult to identify. It begins superiorly on the medial surface approximately midway between the frontal and occipital poles and crossing the superomedial border, extends antero-inferiorly to end just superior to the posterior ramus of the lateral sulcus, 2-3 cm posterior to the origin of the lateral sulcus. The central sulcus is of special importance because it separates the main motor and sensory areas of the cerebral cortex [2].

Central sulcus is also called as fissure of Rolando is a limiting sulcus. It developes in two parts- upper and lower, separated by a transverse gyrus. Later the two parts unite and the gyrus becomes submerged. Thus the depth of the central sulcus is shallow in the middle. Upper end of the sulcus appears partly in the para-central lobule on the medial surface of the hemisphere [3].

Central sulcus is very crucial regarding identification of other sulci on the superolateral surface of the cerebral hemisphere of human brain. So present study was conducted to know the variability in the central sulcus and to add the knowledge to the existing text and reduce confusion regarding identification of sulci on the superolateral surface of cerebral hemisphere among medical tecachers, students and researchers. Sulcus identification is also important among the neurosurgeons while performing lobectomy and other procedures to treat various neurological disorders.

Materials & Methods

Total 80 formalin fixed adult human cerebral hemispheres were examined to study the central sulcus. Brain was removed by dissection method following the Cunningham's dissection manual [2]. Cerebral surface was cleared of arachnoid matter and underlying blood vessels to identify the central sulcus. Distance of the central sulcus from frontal and occipital pole was measured along the superomedial border of cerebral hemisphere using non-elastic tailors measuring tape. Extent of the central sulcus from medial surface to posterior ramus of the lateral sulcus was studied on cerebral hemisphere.

Results

We have studied central sulcus considering different parameters like distance from frontal pole and occipital pole along the superomedial border; whether central sulcus cuts the superomedial border or not, whether it meets posterior ramus of lateral sulcus or not; whether it is interrupted by any gyrus or not. We have tabulated our findings in Table 1,2,3 and 4.

In present study area covered in front of central sulcus upto frontal pole was found to be 50% to 65%; while the area covered behind the central sulcus upto occipital pole ranges from 35.1% to 50% (Table 2).

No central sulcus was found to be interrupted by any gyrus during its course.

Table 1: Distance of the central sulcus from frontal pole (FP) and occipital pole (OP) along the superomedial border

Distance of Central Sulcus	Mean ± SD (cm)	%	Maximum Distance (cm)	Minimum Distance (cm)
From Frontal pole	13.90±0.70	55	16	12.5
From Occipital pole	11.22±0.74	45	12.5	10
Total distance from frontal to occipital pole	25.15±0.89	100	27	22.7

Table 2: Percentage wise distribution of distance of the central sulcus from frontal (FP) and occipital pole (OP)

% wise distribution of area in front and behind the central sulcus	Number of specimens with area covered in front of central sulcus upto FP	Number of cases with area covered behind the central sulcus upto OP
35.1-40%	0	2
40.1-45%	0	36
45.1-50%	0	42
50.1-55%	42	0
55.1-60%	36	0
60.1-65%	2	0

Table 3: Extent of the central sulcus to supero-medial border above and posterior ramus of lateral sulcus

Central sulcus	Supero-median border in number of cases	Posterior ramus of lateral sulcus in number of cases
Does not extend upto	16 (20%)	44 (55%)
Extend upto	64 (80%)	36 (45%)

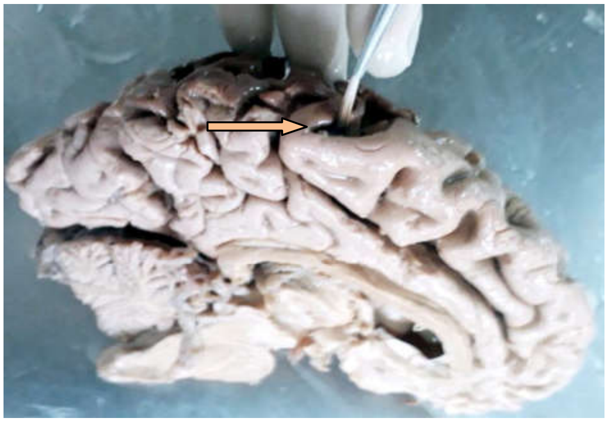

Fig. 1: Arrow shows central sulcus terminating before extending to superomedial border

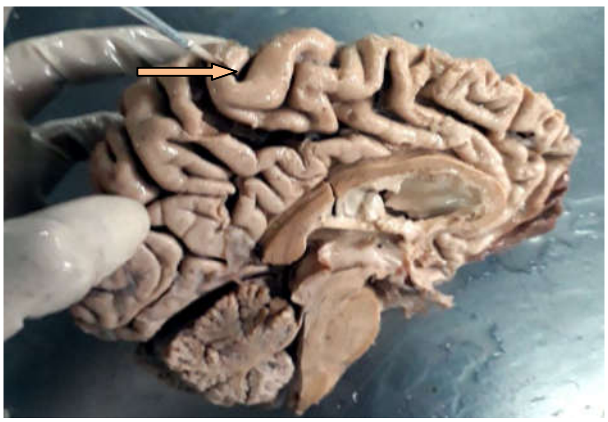

Fig. 2: Arrow shows central sulcus extending beyond the superomedial border on medial surface

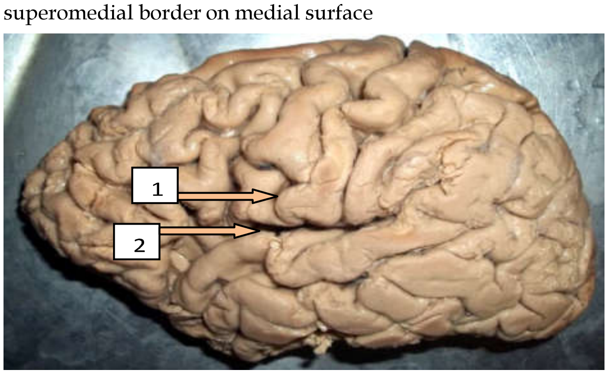

Fig. 3: Arrow showing central sulcus (1) not limited by an arched gyrus and meets the posterior ramus (2)

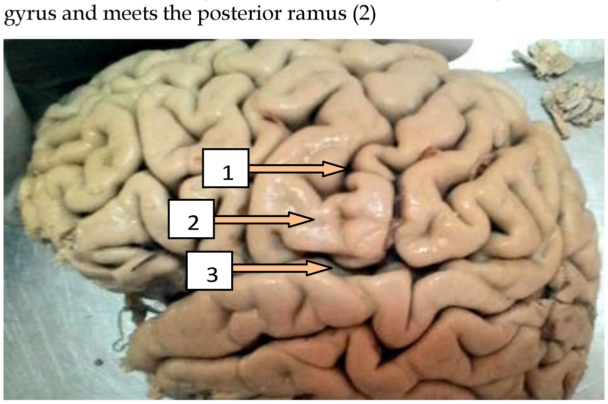

Fig. 4: Arrow showing central sulcus (1) limited by an arched gyrus (2) and doesn't meet the posterior ramus (3)

Discussion

Cortical sulci and gyri attracted little attention until the 19th century, when clinical neurology, neuropathology and comparative anatomy start to unveil the complexity and functional significance of the cortical mantle. This assay is devoted to the Louis Pierre Gratiolet (1815-1865), who was one of the first anatomists to systematically exploit the comparative approach as a tool to map the cortical surface in primates. He undertook a detailed study of brains of human and nonhuman primates and soon realized that the organizational pattern of cerebral convolutions was so predictable that it could serve as a criterion to classify primate groups. He noted that only the deepest sulci exist in lower primate forms, while the complexity of cortical folding increases markedly in great apes and humans. Vicq d'Azyr appears to have been the first to delineate the central sulcus, but he did not name it. It is the French anatomist and alienist François Leuret (1797-1851) who, having apparently misread Vicq d'Azyr's work, associated the name of the Italian anatomist Luigi Rolando (1773-1831) to the central sulcus [4].

The factors that are responsible for the development of the human brain and presumably for such variations across individuals involve both genetic and environmental mechanisms. Genes, however, do not appear to account for most of the variance within a primate species. A study of casts of rhesus macaques found that though brain size is highly heritable, the lengths of most sulci are much less so previously described. In humans, there have been occasional reports of gross inspection of cortical surfaces of stacks, followed by removal of the skull and brains of monozygotic twins, similarities and differences in gyral patterns. Recent preliminary studies of cortical surfaces of human brains suggested likewise, that in monozygotic twins considerable the brains were split into hemispheres, the cerebella and variation in gyral patterns exist. From these various observations it seems that genes influence gyral patterning of the primate brain on a basic level, but that other factors contribute a major portion of the variance across individuals. Anatomical studies in rodents and nonhuman primates have established that genetic programs are major determinants of overall brain size. The differential contributions of genes and environment to the development of gyral patterns are also unknown. Earlier in this century the prevailing view was that gyral size was largely a result of nongenetic mechanical forces. But the existence of taxon, family and genus-specific gyral patterns is evidence of importance of genes [5].

Detailed knowledge of the structure and form of the cerebral sulci and gyri continues to be mandatory for neuro imaging as well as intra-operative guidance. Once identified, the cerebral sulci can be used by the neurosurgeon either as microneurosurgical corridors or simply as cortical landmarks. The macroscopic study of the sulci and gyri of each cerebral hemisphere should therefore begin with the identification of the sylvian fissure, which clearly separates the superolateral surfaces of the frontal, central, and parietal lobes from the temporal lobe, and should be followed by the identification of the precentral and postcentral gyri, which divide the portion of this surface that is superior and posterior to the sylvian fissure into its anterior and posterior halves [6].

The precentral and postcentral gyri are situated obliquely in relation to the interhemispheric fissure, being less serpiginous than the other gyri of the cerebral convexity, and are connected to adjacent gyri via the usual interruptions in the precentral and postcentral sulci. The precentral and postcentral gyri are consistently united inferiorly by the subcentral gyrus and superiorly by the paracentral lobule, which is located on the medial surface of each hemisphere. The precentral and postcentral gyri together resemble an elongated ellipse that is furrowed by the central sulcus, which is usually continuous, and are respectively delineated anteriorly and posteriorly by the precentral and postcentral sulci, which are typically discontinuous. This morphological unit, together with the functional interaction between motricity and sensitivity, justifies the characterization of these gyri as constituting a single lobe [6].

In the study done by Singh GC et al [7] on length and depth of the central sulcus they concluded that the length and depth was found to be more in the left hemisphere than that in the right hemisphere. Mashouf M et al [8] has studied the central sulcus in cadaveric brain specimen. They studied the distance of midpoint of the central sulcus from the frontal pole on superolateral surface of brain and also the length of the central sulcus. Mean (range) distance from right and left frontal pole to midpoint of right and left central sulcuse were 81.27 (55-105) and 82.63 (60-105) mm, respectively. Mean (range) length of right and left central sulcus were 94.85 (75-115) and 97.24 (65-125) mm, respectively.

Therefore after lateral sylvian fissure, central sulcus is important to differentiate between frontal lobe and partial lobe and its gyrus and related functional areas. Knowledge in variability of the central sulcus will be helpful for proper location of the central sulcus and adjacent sulci, gyri and functional areas. When compared with existing study material which state that central sulcus cuts the superomedial border in most of the brain here we found in 20% of the cases central sulcus does not cut the superomedial border of cerebral hemisphere (Figure 1 & 2). Also as stated in previous literature that central sulcus is limited by arched gyri at posterior ramus of lateral sulcus present study shows that limitation by arch gyrus is seen in 55% of cases and rest 45% cases gyrus is not much prominent so central sulcus appear to meet the posterior ramus (Figure 3 & 4). So, this study contributes to the existing knowledge regarding the central sulcus.

Conclusion

Central sulcus is continues one and is shifted more posteriorly i.e. behind the 50% are from frontal pole when measured at superomedial border of cerebral hemisphere. Central sulcus may not always cut the superomedial border and may not always be arched by the prominent arched gyrus at the posterior ramus of the lateral sulcus.

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