Al Ameen J Med Sci 2014; 7(2):141-145 ● US National Library of Medicine enlisted journal ● ISSN 0974-1143

ORIGINAL ARTICLE CODEN: AAJMBG

Variation of the major sulci of the occipital lobe - A morphological study

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Abstract: *Background:* The occipital lobe of cerebrum is intimately related with visual function. The detailed anatomy of this lobe is essential for the surgeons and radiologists. The aim of the present study was to identify the variation of different sulci of the occipital lobe and find the relations between them. So, this study was done to evaluate the different parameters of these sulci by studying cerebral hemispheres morphologically. *Methods:* Total 106 formalin fixed cadaveric brains were studied. The locations and the length (cm) of the calcarine, lunate and parieto-occipital sulcus were studied in detail. Microsoft excel software was utilized to analyze the data. *Results:* The calcarine sulcus in 59.43% had terminated by dividing into two rami. In only 31.13% cases calcarine sulcus met lunate sulcus after reaching the superolateral surface of the hemisphere. Lunate sulcus was of myriad shapes. Though in 49.05% of cases it was convex, in majority of brains it was "f" or "S" shaped. Different hemispheres of the same brain revealed significant variation. *Conclusion:* The study revealed wide variability of the sulci of the occipital lobe. For proper planning of neurosurgical procedures and radiological representation of visual functional areas, detailed knowledge on the variation of these sulci are essential. So, parameters of occipital sulci can permit safer access to deep structures and reduce operative complications.
Keywords: Calcarine sulcus; Lunate sulcus; Parieto-occipital sulcus; Striate cortex.

Introduction

Occipital lobe (OL) of human brain is responsible for proper visual function like interpretation and integration of different visual pathways. The medial cerebral surface is traversed by the calcarine sulcus(CS) and the parieto-occipital sulcus (POS) in the occipital region. Stiate cortex (area 17) lies within the depth and the area surrounding CS and it reaches as far as the lunate sulcus (LS) on the lateral surface of the cerebrum for a short distance (1cm or so). The CS and the POS can be easily identified by the pattern"Y"; the common stem of the "Y" is the anterior part of CS and the two limbs are the POS and posterior part of CS [1].

The deeply infolded cortex of the anterior part of CS corresponds to calcar avis, an elevation in the posterior horn of the lateral ventricle [2]. POS starts on the medial surface, from CS, traverses upwards and backwards to reach the superomedial margin of cerebrum and ultimately ends on the superolateral surface. Grafton Elliot Smith, who named LS, claimed that it was homologous in human and the great apes [3]. It is inconstant, often placed vertically and occassionally joins with the CS. LS is an example of operculated sulcus, have striate and peristriate area around but parastriate area within its depth [2].

These sulci are discernable through magnetic resonance imaging (MRI) and helps in the mapping of the different striate areas in the OL. But there are wide variations of these sulci [4]. The knowledge of the superficial morphological relations of the sulci of this lobe and the identification of its spatial relationship facilitate the approach to sub cortical lesions. It also permits safer access to deep structures, since the posterior horn of the lateral ventricle lies in immediate relationship particularly with the CS. So, the present study

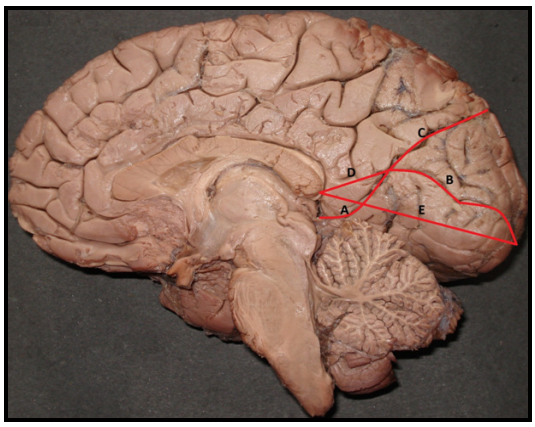
was aimed to evaluate the different parameters and patterns of these sulci by studying cerebral hemispheres morphologically.

Material and Methods

53 brain specimens were obtained following autopsy of the donated cadavers in the Department of Anatomy, Calcutta National Medical College and Medical College Kolkata, India over a period of two years. The specimens were placed in 10% formalin for preservation. Each of the brain was cut through the midline, along the sagittal plane, as such a total of 106 cerebral hemispheres were studied. All the brains were of adult human belonging to both sexes which did not exhibit any apparent abnormal pathology. Age and sex was not considered as a criterion.

The covering meninges and the blood vessels were removed for proper visualization of the sulci. Detailed anatomy of these sulci with respect to the location and termination were studied. The CS was identified in each hemisphere according to standard anatomical criteria [5]. Shape and length of LS was also included in the study. The most discernible sulcus near the occipital pole has been considered as LS. Different lengths were measured taking posterior end of splenium as the reference point using a vernier caliper and thread. The following measurements were taken in centimeters- (as shown in Fig.1). Microsoft excel software was utilized to analyze the data obtained.

Fig-1: Showing different measurements.



A= Length of anterior part of CS.
B= Length of posterior part of CS.
C= Length of POS upto superomedial border.
D= Distance between posterior end of splenium and meeting of POS with CS.
E= Distance from posterior end of splenium to termination of CS in occipital pole.

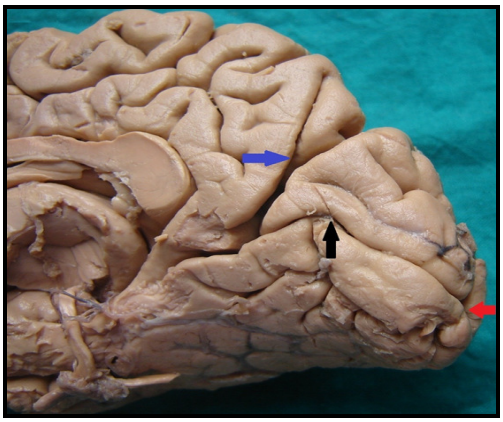
Results

Total 106 cerebral hemishpheres were selected for study, producing 53 hemispheres each of left and the right side. The Table 1 illustrates the summary of the various measurements taken. It shows the variability of the CS, particularly its posterior part where the maximum length was 6.6 cm whereas the minimum being 1.4cm. Many of the POS failed to reach the superolateral surface and in two specimens it had terminated by dividing into two rami (Fig. 2).

Table-1: Parameters of the calcarine sulcus and the parieto-occipital sulcus in occipital lobe with posterior ends of splenium as the reference point

Distance (cm)	Mean ± S.D.	Range
A. Length of anterior part of CS	2.73 ± 9.95	4.03-1.5
B. Length of posterior part of CS	4.12 ± 1.44	6.6-1.4
C. Bifurcation of CS to end of POS	3.42 ± 0.73	5-2
D. Splenium to bifurcation of CS and POS	2.02 ± 0.55	3.3-1
E. Posterior end of Splenium to CS end at occipital pole	5.3 ± 1.11	8-3.2

Fig-2: Blue arrow showing Parieto-Occipital Sulcus dividing into two rami, Black arrow indicating Calcarine Sulcus which met Lunate Sulcus (red arrow).

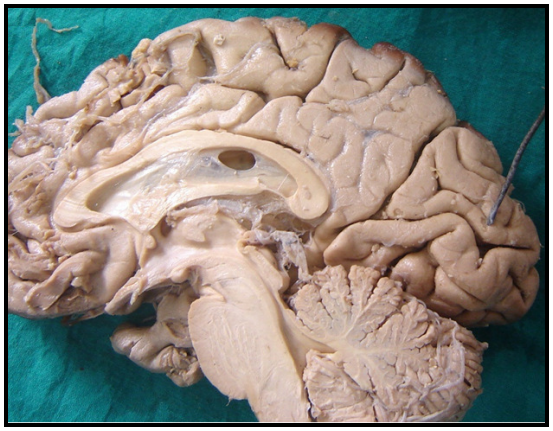


The study revealed that the CS arose from the parahippocampal gyrus in all the cases but is widely variable at its termination. It exhibited rami at its termination in 59.43 % cases (Fig.3) and in four cases had divided twice (Table 2). The rami ran either perpendicular or parallel or at an acute angle to the trajectory of the CS after division. Another revelation of the study was that, in maximum number of cases (68.87%) the CS had not met the LS (Fig.3), had not even crossed the occipital pole in 42.31% cases.

Table-2: Percentage in variation of Calcarine sulcus

	End without division	Divided once at its end	Divided more than once at its end
Total number (n=106)	43	59	4
Percentage	40.56	55.66	3.77

Fig-3: Pointer indicating branching of Calcarine Sulcus, none of the rami meeting Lunate Sulcus.



We had considered the sulcus present near the occipital pole as the LS and it was found extremely variable in its shape and length. Table - 3 illustrates its variability. Though in maximum number of cases it was found to be convex in shape, but in a considerable number of cases (31.13%) it was f/s shaped (Fig.4). In two cases it was X shaped (Fig.5).

The average length of the LS was found to be 2.02 cm±1.05, the maximum being 5cm where as the smallest one was of 1 cm. The patterns of the sulci were not symmetrical in the two hemispheres of the same brain in almost all the specimens we studied.

Fig-4: 'f'/'s' shaped Lunate Sulcus (red arrow) meeting Calcarine Sulcus (black arrow).

Fig-5: 'X' shaped Lunate Sulcus.

Table-3: Percentage in variation of Lunate sulcus

	Convex	Straight vertical	Straight horizontal	Y shaped	f/S shaped	Not discernable	Arch shaped & dividing into rami
Total number (n=106)	52	5	5	4	33	6	1
Percentage	49.05	4.71	4.71	3.77	31.13	5.66	0.94

Discussion

The CS is an important anatomical reference in the medial surface of the OL and is used as a landmark for many clinical diagnosis, surgery and functional studies in the medial surface of the OL. However the data on variation of these sulci are limited. The CS is the most important anatomical reference of the posterior interhemispheric fissure region [6]. Endo S et al**,** showed wide variation in the location of CS, by using positron emission tomography [7]. Our study do not agree with the findings of Iaria G et al, who states that as CS is the longest and the most constant sulci of the occipital region (shown in table 1 &2) [8].

Flores LP [4], after studying 26 brain specimens observed that the CS emerged directly from the parahippocampal gyrus and was variable in termination like ours (Table 4). The percentage of cases where CS crossed the occipital pole is exactly similar to our study.

Table-4: Comparison of parameters of CS

Study	No rami at termination (Percentage)	Divided once (Percentage)	Divided twice (Percentage)	Crossed Occipital Pole (Percentage)	CS met LS (Percentage)
Flores L.P[4] (n=26)	46	38	15	57.69	33.33
Present study (n=106)	40.56	55.66	3.77	57.69	31.13

Table-5: Comparison of lengths of CS and POS

Study	Distance from splenium to termination of CS (cm)	Extension of POS (cm)
Flores LP [4]	5.8	3.5
Ono et al [5]	5.8	3.4
Present study	5.3 ±1.11	3.42±0.73

Table 5 depicts that the lengths of the sulci obtained by our study are quiet similar and comparable with the above studies. As mentioned earlier, for estimation of the visual area, CS is an important landmark. Different degrees of folding may cause the variability of architectonic areas. We have considered only the length here but depth has been studied by various MRI studies [9]. The anatomy of the CS changes in various diseases. Kitajima M et al had reported after performing a magnetic resonance study that, the calcarine area undergoes atrophy in the retinal degeneration [10].

In a study by Allen JS et al using high resolution MRI, the presence, absence and course of the LS were assessed**.** In majority of cases LS identified on the OL were actually composed of smaller sulcal segments that converged into composite LS [3]. Table 3 shows the variability of LS. Though in 49.05 % it was convex in shape – but in a considerable number of cases (31.13%) it was “f “or” s “shaped. A research study had pointed out that in humans the LS are frequently fragmented [11]. Das et al, had reported a case where LS was absent unilaterally on the right cerebral hemisphere [12]. In 6 cases we were also unable to locate LS – and all of them were unilateral- that is the other side had a clearly discernible LS. When LS is not visible in human brains, the primary visual striate cortex is relatively reduced in volume and lies in a posterior position around the occipital pole [11]. The location of LS may serve as a potential marker of the cognitive development in extinct hominid species [3]. For neurosurgeons and radiologists, it is essential to describe different visual functional areas, which is done depending upon the orientation of LS and CS, since they are delineable by MRI. So, exact knowledge of the sulci will enable neurosurgeons to properly interpret the lesions of different visual functional areas and will help the clinicians to correlate its effects. The present study provides an anatomical basis for the knowledge of the variation of these sulci. Meticulous detailing of the occipital lobe needs to be explored by future studies as less data is available regarding depth of CS and LS.

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