

# INTERHEMISPHERIC VARIATION OF SYLVIAN FISSURE: A CADAVERIC BRAIN STUDY

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## ABSTRACT

**Introduction:** Language areas of brain show a beautiful anatomico-functional correlation. It has been often assumed that the interhemispheric asymmetry of Sylvian fissure and perisylvian cortex is the basis of hemispheric dominance for language. The lateral sulcus is one of the earliest-developing sulci of the human brain.

**Materials And Methods:** 60 formalin fixed cadaveric brains irrespective of sexes were studied in the department of Anatomy. The total length of sylvian fissure on the superolateral surface till the posterior sylvian point was noted bilaterally. Among the other measurements taken were the lengths of anterior ascending, anterior horizontal and posterior limb of lateral sulcus till posterior sylvian point on the right and left cerebral hemispheres.

**Observation and Results:** The mean of the total length of the lateral sulcus on the left side is 8.48 which is larger than the right side which is 8.39. The mean of the anterior horizontal rami on right side (1.97) is greater than left side (1.96). On the other hand the mean value of left anterior ascending ramus 2.41 is greater than the mean value of right anterior ascending ramus 2.37. The mean value of posterior limb of sylvian sulcus is also greater on the left side i.e. 6.43 than on the right side i.e. 6.23. All measurements are in cms.

**Conclusion:** The Sylvian fissure in this study is longer on the left side than the right which has been proved in previous studies. To correlate this structural asymmetry with the functional localization of speech and language calls for further studies.

**KEY WORDS:** Sylvian fissure, lateral sulcus, anterior Sylvian point, posterior Sylvian point.

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## INTRODUCTION

Anatomical brain asymmetries are subtle and still little studied in humans. Among all the animals, humans have the most asymmetric brains Crow [1]. The two cerebral hemispheres are the largest major divisions of the brain. Each hemisphere consists of an external highly convoluted cortex, beneath which lies an extensive mass of white matter that partly encloses

the basal ganglia. Clinically and with respect to functional neuroimaging, speech and language are one of the most lateralized of all cerebral functions. Their cortical areas are also some of the most asymmetrical in the brain. These areas are located within the pars opercularis (PO) and pars triangularis (PT) in the frontal lobe. They are bounded anatomically by the anterior horizontal ramus of the Sylvian fissure (SF),

anterior ascending ramus of the SF. They are also used as anatomical boundaries to estimate gyral volume of these regions. Each cerebral hemisphere may be considered to have superolateral, medial and inferior (basal) surfaces. Two prominent sulci, the lateral (sylvian) sulcus and central sulcus are the main features on the superolateral cerebral surface. The lateral sulcus is a deep cleft on the lateral and the inferior surface Sylvian fissure anatomy in the human brain is very variable and no agreement exists as to the point of its posterior termination. The basic asymmetry is in the position at which the fissure turns up, resulting in the different extent and position of the surrounding right and left parietal and temporal lobes, Witelson and Kigar [2]. It commences inferiorly at the anterior perforated substance extending laterally between the orbital surface of frontal lobe and the anterior pole of temporal lobe. Reaching the lateral surface of the hemisphere it gives rise to an ascending ramus which runs into the inferior frontal gyrus. The larger posterior ramus runs posteriorly and slightly upwards, across the lateral surface of the hemisphere to end in the parietal lobe as shown in Fig 1. 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 and runs downwards and forwards to end a little above the posterior ramus of the lateral sulcus.

The major sulcal contours and rami of the sylvian fissure was used to demarcate the pars opercularis and pars triangularis from adjacent cortex are easily identifiable and ordinarily form simple and easy to follow contours. The horizontal ramus appears like a continuation of sylvian fissure from the surface of brain, whilst the ascending ramus appears as a deep fold oriented perpendicular to the sylvian fissure. However analysis of inter-individual variation in large samples has shown great diversity in the morphology of these sulci and rami, as shows in some studies Keller et al [3]. Such variability has a great impact on quantification design. Some anatomical features occasionally cannot be visualized from the surface of the brain and therefore intrasulcal anatomy must be explored.

Sulci and rami may in some brains, not be continuous and parts of the course of the sulci has to be interpolated.

**Aim:** The aim of the present study is to observe the interhemispheric differences of the fissural patterns of the Sylvian fissure.

The objectives of the study are as follows:

- To quantify and measure the segments and length of each segment of Sylvian fissure on the superolateral surface of cerebral cortex.
- To analyse the normative data of the above and compare interhemispheric differences.

To observe the overall shape, size and sulcal patterns of Sylvian fissure, anterior sylvian point and branching pattern of anterior horizontal and anterior ascending rami from it, thus to observe the gross anatomical details in both hemispheres.

## MATERIALS AND METHODS

The present study was done in 60 formalin fixed adult brain specimens irrespective of sexes in the Department of Anatomy.

The brain specimens preserved in Bouin's fluid and freshly removed brain specimens from the embalmed bodies were used.

**Inclusion Criteria:** Adult brain specimens with intact bilateral cerebral hemispheres having no damage or gross deformity.

**Exclusion Criteria:** Infant and adolescent brains, brains in which the superolateral surface were damaged, gross morphological variation or deformity on the surface and post mortem brain specimens.

The lateral sulcus or the sylvian fissure was observed in detail for each segment and its termination. The lateral sulcus was measured on the superolateral surface. All measurements were taken with the help of black silk suture material placed on the surface and either ends were held with artery forceps for accuracy. Measurements were taken from the scale fixed on the surface and noted down in the observation sheet previously prepared. The branching pattern of the anterior ascending, anterior horizontal from the anterior sylvian point and continuation of sylvian fissure till the posterior sylvian point was observed. The

anterior ascending, anterior horizontal and posterior limbs of lateral sulcus were measured with similar techniques and measurements were tabulated. The termination of sylvian fissure was noted for its bifurcation. All data collected was subjected for statistical analysis.

**OBSERVATIONS & RESULTS**

The sylvian fissure was observed for its beginning, anterior sylvian point, anterior ascending, anterior horizontal, posterior limb till its bifurcation at the posterior sylvian point.

The anterior ascending and anterior horizontal rami of the SF arose from the anterior sylvian point and either divides at this point giving a U- or V-shaped anterior ascending and anterior horizontal rami of the SF, or have a common stem which separates distally giving anterior ascending and anterior horizontal rami. The anterior ascending and anterior horizontal rami of the SF was U-shaped in 43.3% (52/120), V-shaped in 35% (42/120), common stem in 21.6%(26/120). The right hemispheres had a U-shaped and V-shaped configuration of the anterior ascending and anterior horizontal rami, common stem later bifurcating at anterior sylvian point in 53.3%(32/60), 33.3%(20/60), and (13.3)8/60 hemispheres respectively; this was 33.3%(20/60), 33.6(22/60), and 30%,(18/60) on the left respectively.

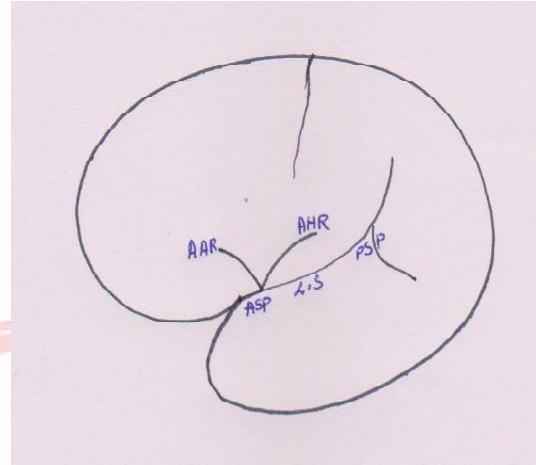
The Fig 2 shows the branching pattern of the anterior ascending and anterior horizontal rami from the anterior sylvian point which has a U shaped configuration which is the most common pattern in this study.

The Table 1 compares the total length of sylvian sulcus on the right and left sides and the mean length on the right side is 8.3958 and on the left side is 8.4892 the mean value on the left side is greater than the right side.

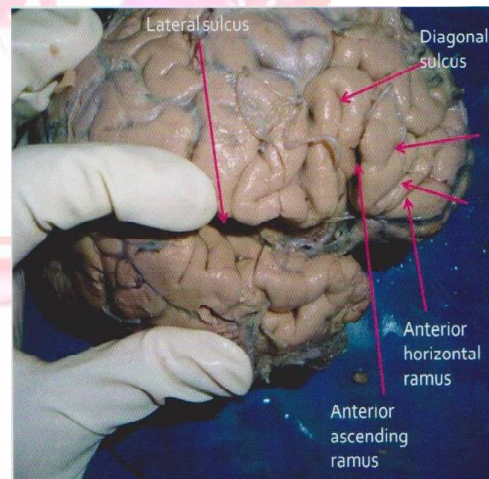
The mean value of right horizontal ramus 1.9798 is greater than the mean value of left horizontal ramus which is 1.9606. On the other hand the mean value of left anterior ascending ramus 2.4114 is greater than the mean value of right anterior ascending ramus. Similarly the mean value of posterior limb of sylvian sulcus is also greater on the left side i.e. 6.43 than on the right side i.e.6.23. After calculating the mean,

standard deviation of each parameter is derived. The bar diagram of the Fig 3 compares the means of sylvian sulcus and its segments. All measurements are taken in cms.

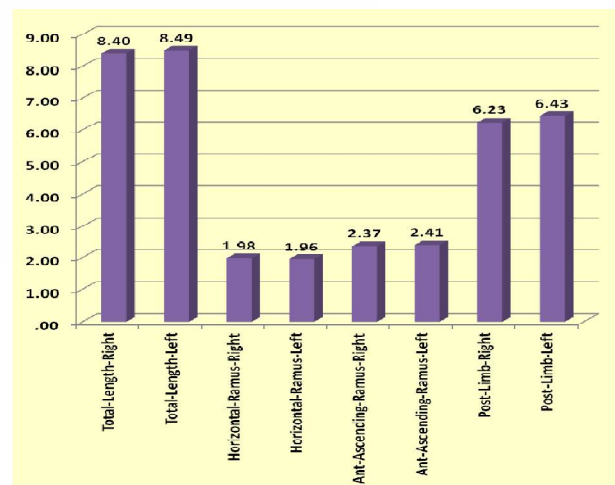
**Fig. 1:** LS- lateral sulcus, PSP- posterior Sylvian point, ASP- anterior Sylvian point, AAR- anterior ascending rami, AHR – anterior horizontal rami.



**Fig.2:** Shows the lateral sulcus (LS), the anterior horizontal (AHR) and anterior ascending rami (AAR).



**Fig. 3:** Compares the means of total length of lateral sulcus ,means of anterior horizontal rami ,means of anterior ascending rami ,means of posterior limbs, of right and left cerebral hemispheres.



**Table 1:** Compares the statistics of the parameters studied.

Characteristics	Number	Range	Minimum	Maximum	Sum	Mean		Standard Deviation	Variance	Skewness		Kurtosis		95% Confidence Interval for Mean	
		Statistic	Statistic	Statistic	Statistic	Statistic	Standard Error	Statistic	Statistic	Statistic	Standard Error	Statistic	Standard Error	Lower Bound	Upper Bound
Sylvian Sulcus Total Length Right	60	4.85	5.75	10.6	503.75	8.3958	0.131	1.0147	1.0295	-0.27	0.31	0.54	0.61	8.1337	8.6579
Sylvian Sulcus Total Length Left	60	5.55	5.65	11.2	509.35	8.4892	0.1336	1.0351	1.0715	-0.37	0.31	0.87	0.61	8.2218	8.7566
Sylvian Sulcus Horizontal Ramus Right	60	3.8	0.4	4.2	118.79	1.9798	0.0919	0.7118	0.5067	0.67	0.31	0.46	0.61	1.796	2.1637
Sylvian Sulcus Horizontal Ramus Left	60	2.5	1.1	3.6	117.636	1.9606	0.0766	0.5933	0.352	0.73	0.31	-0.02	0.61	1.8073	2.1139
Sylvian Sulcus Anterior Ascending Ramus Right	60	3.1	0.9	4	142.34	2.3723	0.0799	0.6188	0.3829	0.09	0.31	0.02	0.61	2.2125	2.5322
Sylvian Sulcus Anterior Ascending Ramus Left	60	2.8	0.8	3.6	144.682	2.4114	0.0791	0.613	0.3758	-0.34	0.31	0.1	0.61	2.253	2.5697
Sylvian Sulcus Posterior Limb Right	60	4.06	3.91	7.97	373.78	6.2297	0.1451	1.1243	1.264	-0.46	0.31	-0.92	0.61	5.9392	6.5201
Sylvian Sulcus Posterior Limb Left	60	5.04	4	9.04	386.085	6.4348	0.1473	1.141	1.3019	-0.36	0.31	-0.31	0.61	6.14	6.7295

## DISCUSSION

Although the earliest comparative assessment of Sylvian fissure morphology was made by Cunningham [4] who measured its length in a series of primate genera including pan, pongo, macaca, papio, cerocebus and cebus, no consistent pattern of hemisphere asymmetry was identified. A much later but similar comparative study of the lengths of lateral sulcus conducted in humans, chimpanzees and macaques by Yeni-Komshian and Benson reported that the lateral sulcus was significantly leftward asymmetric in humans, also to a lesser degree in chimpanzee but symmetric in macaques [5].

Interestingly it has been noted previously that orangutans might be more likely to help in understanding the evolution of handedness or languagethan studies in chimpanzees Le May [6]. Similarly he had also noted a leftward asymmetry of the LS/SF to be particularly common in Pongo (Orangutans). Cerebral asymmetries are similar both in modern and in fossil humans. Most frequent among these is the lateral sulcus, which may be found not only in humans, but also in monkeys, chimpanzees and orangutans, albeit in less conspicuous form in these latter animals Yemi-Komshian & Benson [5].

Witeson and Pallie (1973) found asymmetries in the planum temporale of newborn as well as adult human brains with 86 percent of the newborn brains and 81 percent of adult brains having a larger planum temporale on the left than on the right [7].

The data from the brains of newborns suggest that the anatomical asymmetry associated with language function is present in the human before the onset of language learning and preferred hand usage.

Leftward symmetries of the adjacent sylvian fissure in human brains were first demonstrated by Eberstaller [8] then confirmed and expanded by Cunningham [4]. A recent study of the sylvian fissure in old and new world monkey brains used an anatomic magnetic resonance imaging approach. Hopkins et al. demonstrated that both Old and New world monkeys had leftward asymmetry of sylvian fissure [9].

The sylvian fissure has long been shown to be an important indicator of the leftward cerebral asymmetry present in human language reception regions. Studies on the lengths of human sylvian fissures have found the left to be longer than the right by Connelly CJ, as it is confirmed by the present study [10].

In a recent study of SF on 62 cadaveric adult

hemispheres by Olufemi et al., the sylvian fissure length on the right (mean=84.3mm, median=88mm) was significantly shorter than that on the left (mean=89.4mm, median=92mm). The left SF was significantly longer than the right and both were positively correlated. In the present study the length of sylvian sulcus on the right and left sides and the mean length on the right side is 8.3958 and on the left side is 8.4892 the mean value on the left side is greater than the right side [11]. In another study by Boni R.C et al on 42 postmortem adult brains the lateral sulcus in the right hemisphere had a median of 65.11mm and in left hemisphere 79.94mm (16.6% higher in left hemisphere) [12]. Even in this present study the mean of the total length of the lateral sulcus on the left hemispheres is 8.49 compared to the mean in right hemispheres 8.40. In a *in vivo* MRI surface renderings study by Foundas A.L SF asymmetries were studied in a group of right handed men and women there was significant leftward asymmetry of horizontal SF in men and women but sex related effects do not exist in consistently in right handed subjects [13].

The anterior ascending rami demarcates the pars triangularis from pars opercularis whereas the anterior horizontal rami demarcates the pars triangularis from the pars orbitalis. In another study three segments of the sylvian fissure were defined and measured: anterior, horizontal, and vertical. The anterior segment showed no asymmetry; the horizontal segment was twice as large on the left side as on the right; and the vertical segment twice as large on the right. The two asymmetries counterbalanced each other. The basic asymmetry is in the position at which the fissure turns up, resulting in the different extent and position of the surrounding right and left parietal and temporal gyri and associated cytoarchitectonic regions. Witelson and Kigar [2]. In the present study the mean of anterior ascending rami is 2.37 on the right hemispheres, 2.41 on the left hemispheres respectively. The mean of the posterior limb of the lateral sulcus in this present study which corresponds to the horizontal segment of the above study was greater on the left hemisphere (6.23 on the right and 6.43 on the left) whereas the anterior horizontal rami (mean on right

hemisphere 1.98 and on left hemisphere 1.96) was greater on the right hemispheres. The anterior ascending rami of the SF may be absent. Ono et al., detected the absence of anterior ascending rami in 86.66% (13/15) of the right hemispheres and in 93.33% of the (14/15) left hemispheres [14]. In our study and the study conducted on 62 hemispheres by Olufemi et al. the anterior ascending rami was present in all the hemispheres. The anterior horizontal and anterior ascending rami of the SF had three major configurations. The most common noted in this study was the U- and V-shaped, both accounting for almost 78%. In the study by Olufemi et al the U and V shaped configuration of branching of anterior ascending and anterior horizontal was seen in 70%. This is at variant to study conducted by Ayberk et al. which showed the branching pattern after the common stem in 39.3% (11/28) and 28.6% (8/28) each with V-shaped and U-shaped configuration [15].

## CONCLUSION

In this study the gross morphological asymmetry obtained pertaining to the lateral sulcus and perisylvian cortex can be a determinant or even related to language lateralisation of human brain. Further studies are necessary to strongly establish the relation between the structural and functional asymmetries between both the cerebral hemispheres concerning speech and language lateralisation, This study thus adds to the existing literature.

**Conflicts of Interests: None**

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