

## A CADAVERIC STUDY OF THE STRUCTURAL VARIATIONS IN THE PATTERN OF ORBITAL SULCUS IN HUMAN BRAIN

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Received : 17/09/2024  
Received in revised form : 08/11/2024  
Accepted : 22/11/2024

Keywords:  
Brain, Orbital Sulcus, Variation.

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DOI: 10.47009/jamp.2024.6.6.96

Source of Support: Nil,  
Conflict of Interest: None declared

Int J Acad Med Pharm  
2024; 6 (6); 504-507



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### Abstract

**Background:** The Orbital Sulcus is an H-shaped sulcus on the orbital surface of the frontal lobe. The pattern of the orbital sulcus is variable and has been classified into three types. The aim of this study was to determine the pattern of the orbital sulcus and whether there are any significant differences in these patterns between hemispheres. **Materials and Methods:** A cross-sectional study of 24 embalmed adult brains was done from April, 2023 to October, 2023. The patterns of the orbital sulcus were studied, and the prevalence of each pattern type was determined. The differences in the prevalence between hemispheres were analyzed. **Result:** Type I was present in 13 hemispheres (27%), Type II in 25 hemispheres (52%) and Type III in 10 hemispheres (21%), out of a total of 48 cerebral hemispheres. **Conclusion:** The most prevalent pattern in this study was found to be the Type II pattern. The Type III pattern has been associated with premature birth and observed in patients with schizophrenia and substance abuse disorders. These associations need further investigation to see whether they can be considered as a marker for psychiatric disorders.

## INTRODUCTION

The orbitofrontal cortex is located on the inferior surface of the frontal lobe. It is responsible for emotional processing, motivation, decision-making, goal directed behavior and memory.<sup>[1]</sup> Lesions here result in apathy, social withdrawal, socially inappropriate behavior, depressed mood, affective instability and diminished ability to identify emotional expression.

The Orbital Sulcus is an H-shaped sulcus on the orbital surface of the frontal lobe. There are two longitudinal limbs denoted as Medial Orbital sulcus and Lateral Orbital sulcus. They are joined by a transverse limb called the Transverse Orbital sulcus.<sup>[1]</sup> The medial and lateral limbs may be further divided into anterior and posterior parts.<sup>[1]</sup>

The pattern of the orbital sulcus is variable and has been classified into three types by Chiavaras and Petrides.<sup>[1]</sup> [Figure 1]. This classification has also been followed by other authors for studies concerning the orbital sulcus.

Different pattern types have been associated with conditions like schizophrenia and long term cannabis use. The Type III pattern has been found more frequently in long term cannabis users and hence may

help in determining individuals at a higher risk of developing long-term cannabis use.<sup>[2]</sup> Patients with psychosis have been found to have an increased prevalence of Types II and III patterns in the right hemisphere. This implies that these patterns could be used as markers of schizophrenia.<sup>[3-10]</sup>

The aim of this study was to determine the prevalence of different pattern types of the Orbital Sulcus in Human brains and whether there is any significant difference between hemispheres.

## MATERIALS AND METHODS

A cross-sectional observational study of 24 embalmed, formalin fixed adult brains was conducted at the Department of Anatomy, Gauhati Medical College. The study period was from April 2023 to October 2023. Both hemispheres of each brain were included in the study. The specimens were obtained from cadavers in the Department of Anatomy and the Department of Forensic Medicine and Toxicology, Gauhati Medical College Assam. The cadavers were either donated for educational purposes or used for medicolegal investigations.

### Inclusion Criteria

- Adult human brains irrespective of gender.

### Exclusion Criteria

- Any brain that exhibited decomposition, pathological changes, or physical damage.

The brains were removed from the cadavers carefully and stored in 10% formalin at room temperature. The olfactory sulcus was identified by removing the olfactory bulb. The orbital sulcus was identified and the pattern of the sulcus was categorized for each hemisphere as per the classification by Chiavaras and Petrides.<sup>[1]</sup>

### The types are described as follows:

- Type I – medial orbital sulcus is separated into anterior and posterior sections, and a continuous lateral orbital sulcus is present.
- Type II – The anterior and posterior sections of both medial and lateral orbital sulci are connected to form continuous sulci. Both sulci are connected to transverse orbital sulcus, forming the classical “H-pattern.”
- Type III – The anterior and posterior sections of both medial and lateral orbital sulci are separate.

A Type IV pattern was described by Chakirova et al,<sup>[3]</sup> in 2010. However, it is considered by other authors to be a subtype of Type III.<sup>[9]</sup> Hence, in this study, the initial classification of three types was used and any Type IV patterns found were considered as Type III.

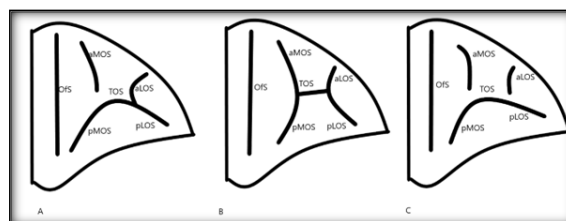
## RESULTS

The sample consisted of 24 brains, resulting in a total of 48 hemispheres studied.

Type I was present in 13 hemispheres (27%), Type II in 25 hemispheres (52%) and Type III in 10 hemispheres (21%). The right hemispheres consisted of 7 Type I, 15 Type II and 2 Type III. The left hemispheres consisted of 6 Type I, 10 Type II and 8 Type III.

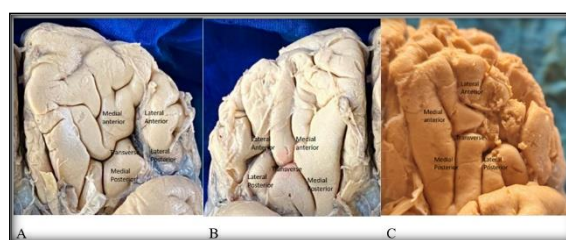
The most prevalent pattern was Type II in both the right (62.5%) and left (42%) hemispheres.

No significant difference in pattern types between hemispheres was noted ( $p=0.3107$ ).

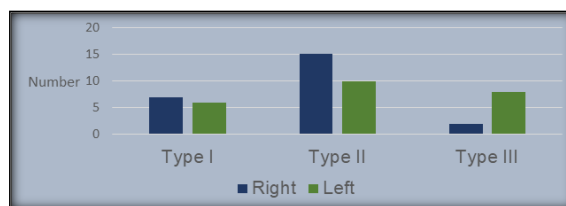


**Figure 1: Orbital sulcus pattern types – Type I(A), Type II(B) and Type III(C).**

Abbreviations: aMOS-Medial orbital sulcus anterior part, pMOS-Medial orbital sulcus posterior part, aLOS-Lateral orbital sulcus anterior part, pLOS-Lateral orbital sulcus posterior part, TOS-Transverse orbital sulcus, OfS-Olfactory sulcus.



**Figure 2: The orbital sulcus pattern types observed in this study. A: Type I, B: Type II, C: Type III.**



**Figure 3: Distribution of pattern types in both Hemispheres**

**Table 1: Distribution of pattern types in both hemispheres.**

	Right Hemisphere	Left Hemisphere	Total
Type I	7	6	13(27%)
Type II	15	10	25(52%)
Type III	2	8	10(21%)

**Table 2: Prevalence of orbital sulcus types reported in the literature**

Author, sample size	Country, Type of study	Type I	Type II	Type III
Current study n=48	India Dissection	13(27%)	25(52%)	10(21%)
Chiavaras et al, <sup>[1]</sup> n=100	Canada MRI	56(56%)	30(30%)	14(14%)
Uehara-Aoyama et al, <sup>[5]</sup> n=188	Japan MRI	101(54%)	59(31%)	28(15%)
Nakamura et al, <sup>[8]</sup> n=200	USA MRI	95(48%)	66(33%)	39(20%)
Takayanagi et al, <sup>[6]</sup> n=154	Japan MRI	71(46%)	52(34%)	31(20%)
Els et al, <sup>[14]</sup> n=86	South Africa Dissection	27(31%)	28(33%)	31(36%)
Bartholomeus et al, <sup>[4]</sup> n=338	Australia MRI	177(52%)	72(21%)	89(26%)
Lavoie et al, <sup>[7]</sup> n=368	Australia MRI	181(49%)	77(21%)	110(30%)
Watanabe et al, <sup>[13]</sup> n=210	Japan MRI	111(53%)	59(28%)	40(19%)
Whittle et al, <sup>[11]</sup> n=304	Australia MRI	174(57%)	76(25%)	54(18%)
Cropley et al, <sup>[9]</sup> n=352	Australia MRI	185(53%)	71(11%)	82(23%)
Takahashi et al, <sup>[15]</sup> n=324	Japan MRI	187(58%)	38(12%)	99(31%)
Rodrigues et al, <sup>[16]</sup> n=84	Brazil Dissection	35(42%)	31(37%)	18(21%)
Sarkar et al, <sup>[17]</sup> n=94	India Dissection	52(55%)	16(17%)	22(23%)
Nishikawa et al, <sup>[10]</sup> n=466	Japan MRI	285(61%)	52(11%)	129(28%)

Ganella et al. <sup>[12]</sup> n=682	Australia MRI	347(51%)	128(19%)	207(30%)
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## DISCUSSION

In the present study, Type I was found in 27% hemispheres. This is lower than the prevalence reported in previous studies (31–61%). The prevalence of Type II was 52%, which is higher than the range reported in studies (11–37%), while Type III (21%) was observed to fall within what was reported by other studies (14–36%).

The differing prevalences of Type I and Type II in our study could be due to the smaller sample size. Moreover, the majority of other studies were done using radiological techniques such as MRI, while the current study was cadaveric.

No significant differences in the prevalence of pattern types were observed between left and right hemispheres in this study, which is similar to the findings of other studies.<sup>[1,2,4,5,9,11]</sup>

Gyrification of the orbitofrontal cortex mostly occurs in the third trimester and is completed shortly after birth.<sup>[12]</sup> Thus, preterm births may result in variant patterns of the orbital sulcus. The sulcal pattern remains constant after this period and hence will be present before any clinical conditions. They may therefore be used as a marker to predict increased risk of long-term cannabis use or schizophrenia.<sup>[3,8]</sup>

The Type III pattern was observed in about a fifth of our sample. Individuals with a Type III pattern in the right hemisphere have been reported in previous studies to have used cannabis for longer than individuals with Type I or Type II patterns.<sup>[2]</sup>

The folding of the gyrus that is associated with Type I pattern may result in more effective neuronal connections with other brain regions than Type II and Type III.<sup>[7]</sup> Hence, the decreased expression of Type I may indicate increased risk of psychosis. The Type I pattern has also been suggested to represent a resilience marker against schizophrenia.<sup>[9]</sup>

A decreased expression of Type I (49%) in patients falling under autism spectrum disorders as compared to controls (56%) was observed by Watanabe et al. They also saw an increase in Type III (22%) against controls (11%).<sup>[13]</sup>

**Limitations:** There are some limitations that occurred due to the cadaveric aspect of this study. Medical histories were not available; thus, it is unknown whether individuals with Type III pattern were born premature or suffered from schizophrenia, depression, or psychosis. There was also no information available about the individuals' lifestyles and habits, including drug and alcohol consumption.

## CONCLUSION

In this study, Type II was the most prevalent pattern type of orbital sulcus found. It was also at a higher prevalence than that reported by other studies, while the prevalence of Type I was lower than that reported in the literature.

An association may exist between orbital sulcus pattern type and preterm birth, psychiatric or substance abuse disorders. Further studies are required to determine this. These variations in pattern may be used as markers for an increased risk of long-term cannabis use or psychiatric disorders, such as schizophrenia, and hence warrants further coordination between neurologists and anatomists.

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