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ORIGINAL COMMUNICATION

The Subparietal and Parietooccipital Sulci: An Anatomical Study

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The subparietal and parietooccipital sulci are both located on the medial surface of the brain. Both of these sulci reveal significant variability in pattern and complexity. Both subparietal and parietooccipital sulci play an important role as surgical landmarks using posterior interhemispheric parietooccipital approach to lesions located adjacent to the ventricular trigon deep to the cingulate gyrus. The aim of this study is to analyze variations in the patterns of the subparietal and parietooccipital sulci and to emphasize their surgical importance. Fifty-six formalin-fixed cadaveric cerebral hemispheres from 28 adult humans are examined. Subparietal and parietal sulci patterns, variations and their relationship with the cingulate sulcus are studied according to the terminology introduced by Ono et al. The H-pattern was observed in 50% (n = 28) of all hemispheres, being the most common pattern of the subparietal sulcus. The Straight pattern was observed in the 30.4% (n = 17) of all hemispheres, being the most common pattern of the parietooccipital sulcus. Furthermore, more detailed results among the patterns, connections, side branches and the relationship with the adjacent sulci are given. Our study further confirms the complexities in the patterns of the subparietal and parietooccipital sulci and demonstrates that these sulci fall within an expected range of variations. Better knowledge of these variations will further help neurosurgeons to navigate easily during approaches involving the medial surface of the parietal lobe. Clin. Anat. 26:667–674, 2013.

Key words: anatomy; parietooccipital sulcus; pattern; precuneus; subparietal sulcus

INTRODUCTION

Following the development of microneurosurgical techniques and the transcisternal, transfissural, and transsulcal approaches, sulci have become the main surface landmarks and possible corridors for approach to deeply seated brain lesions (Yasargil et al., 1976; Harkey et al., 1989; Pia, 1986; Yasargil, 1984, 1988, 1994, 1996; Ribas et al., 2006; Nishikuni and Ribas, 2013). Consequently, neurosurgeons must have sufficient knowledge of the sulcal anatomy and their variations to allow for a safe neurosurgical approach while conserving the normal function. Sulcal patterns of the human brain have been widely studied and their complexity, variability and asymmetry between the left and right hemispheres have been well documented (Eberstaller, 1884; Retzius, 1896; Ono et al., 1990; Paus et al., 1996).

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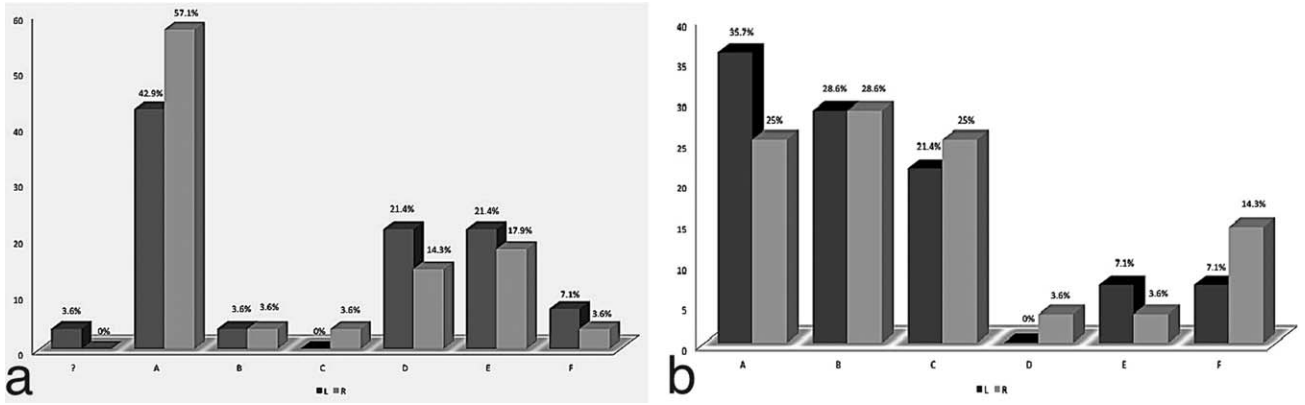

Fig. 1. (a) Bar-graph showing the percentages of the subparietal sulcus patterns. (A: H-pattern; B: split-H pattern; C: Oblique pattern; D: single upward branch pattern; E: triple upward branch pattern; F: double horizontal sulci pattern; ?:unidentified pattern.). L: left hemispheres; R: right hemispheres. **(b)** Bar-graph showing the percentages of the parietooccipital sulcus patterns. (A: straight; B: T- or Y-shape; C: ramified to three branches with inferior branch directed posteriorly; D: ramified to three branches with inferior branch directed anteriorly; E: one anteriorly directed large side branch present; F: one posteriorly directed large side branch present). L: left hemispheres; R: right hemispheres.

The subparietal sulcus (SS) and parietooccipital sulcus (PS) are both located on the medial surface of the brain. The SS follows the original course of the cingulate sulcus posteriorly from where the marginal ramus of the cingulate sulcus bends superiorly. It also separates the precuneus superiorly from the posterior segment of the cingulate gyrus (Williams and Warnick, 1986). The human SS displays significant variability in shape and complexity (Ono et al., 1990).

The PS courses inferiorly from the vertex to merge with the calcarine sulcus, just posterior to the splenium of the corpus callosum. It comprises the boundary between the precuneus and the cuneus, as well as the boundary between the parietal lobe and the occipital lobe (Williams and Warnick, 1986).

Neurosurgical approaches to lesions located adjacent to the ventricular trigon deep to cingulate gyrus are challenging. The posterior interhemispheric parietooccipital approach was first described by Yaşargil (Yasargil, 1996; Yasargil and Abdulrauf, 2008; Wang et al., 2010). With this approach, potential injury to the optic radiation and the visual cortex is avoided. Thus, as a surgical landmark on the medial surface of the brain, the knowledge of the anatomic variations of the SS and PS is paramount to a careful surgical plan.

In this study, the patterns and variations of the SS and PS and their branches are evaluated using the previously described landmarks and terminologies (Ono et al., 1990). The aim of this study is to analyze variations in the patterns of the SS and PS, and to emphasize the surgical importance of these sulci during the interhemispheric approaches to the ventricular trigon and the cingulate gyrus.

MATERIALS AND METHODS

Fifty-six formalin-fixed cadaveric cerebral hemispheres from 28 adult humans are examined. All brains are from subjects with no known neurological or psychiatric history. The brains are removed from the skull and suspended in 10% buffered formalin for at least 4 weeks of immersion fixation. Following fixation, the cerebellum and brainstem are separated from the rest of the brain and the cerebral hemispheres separated by cutting the corpus callosum through the median plane. The arachnoid and cerebral vessels are carefully peeled off to expose the sulci on the medial surface of each hemisphere. Each specimen is photographed at a distance of 50 cm using a Nikon D5000 high-resolution digital camera (Nikon Co., Tokyo, Japan). The cingulate sulcus, its marginal branch, SS, and PS are traced on digital images using Adobe Photoshop CS5 (Adobe Systems Incorporated, San Jose, CA).

The main focus of this study is the SS, PS and their relationship with the cingulate sulcus. In order to maintain uniformity, we employed the terminology introduced by Ono et al. (1990), and observations were made in each hemisphere.

RESULTS

The SS was present as a short main-sulcus composed of several branches, whereas the PS was an uninterrupted large main sulcus in 100% of the hemispheres examined.

SS Patterns

H-pattern. The H-pattern was observed in 50% (Figs. 1a and 2a) (n = 28) of all hemispheres, being the most common pattern of the SS. Twelve (42.9%) left hemispheres showed the H-pattern, whereas 16 (57.1%) H-patterns were identified in the right hemispheres.

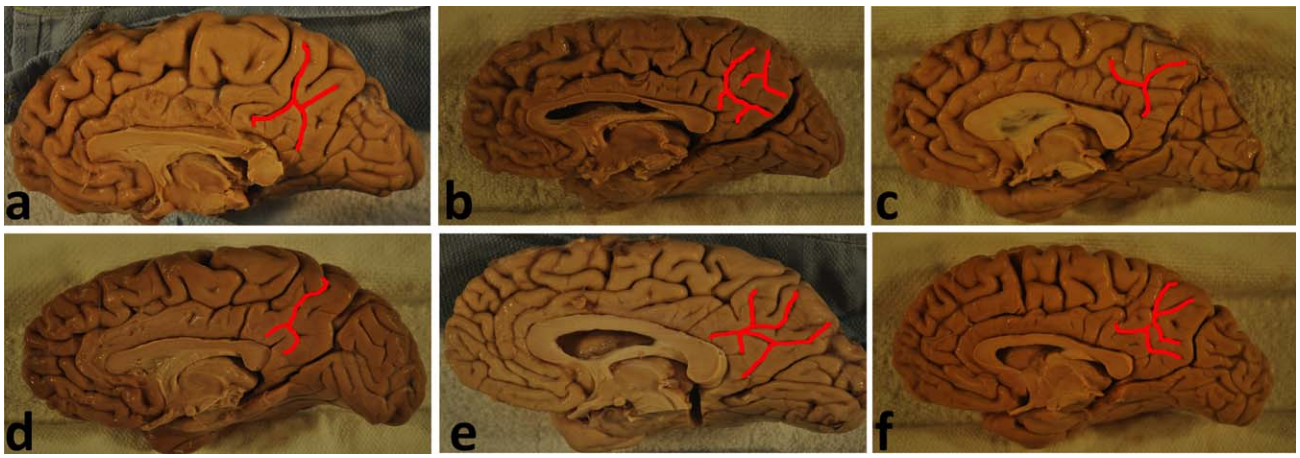

Fig. 2. Photographs demonstrating the subparietal sulcus patterns: H-pattern (**a**); split-H pattern (**b**); Oblique pattern (**c**); single upward branch pattern (**d**); triple upward branch pattern (**e**); double horizontal sulci pattern (**f**).

Split-H pattern. A split-H pattern was observed only in two of the hemispheres (Fig. 2b) (3.6%); one is in a right and the other is in a left hemisphere.

Oblique pattern. An oblique pattern was observed only in one right hemisphere (Fig. 2c) (1.8%).

Single upward branch pattern. A single upward branch pattern was observed in 17.9% of (Fig. 2d) (n = 10) all hemispheres. Six (21.4%) of the left hemispheres and four (14.3%) of the right hemispheres had single upward branch pattern.

Triple upward branches pattern. A triple upward branch pattern was observed in 19.6% (Fig. 2e) (n = 11) of all hemispheres, being the second-most common pattern. Six (21.4%) of the left hemispheres and five (17.9%) of the right hemispheres had a triple upward branch pattern.

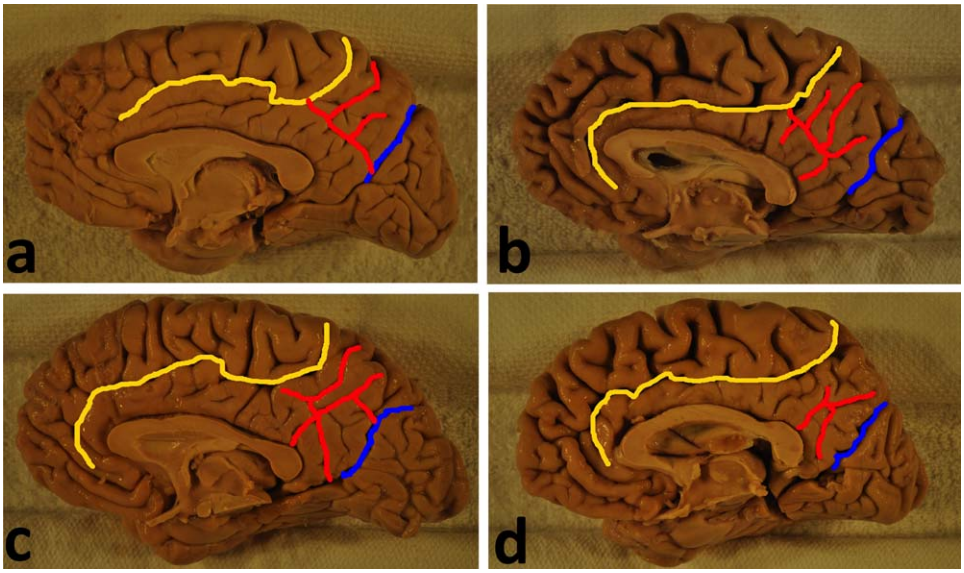

Fig. 3. (a)Photograph of the medial surface of a left hemisphere demonstrating the subparietal sulcus (red) connection both with cingulate sulcus (yellow) and parietooccipital sulcus (blue). **(b)** Photograph of the medial surface of a left hemisphere demonstrating the subparietal sulcus (red) has connection only with cingulate sulcus (yellow). There is no connection with parietooccipital sulcus (blue). **(c)** Photograph of the medial surface of a right hemisphere demonstrating the subparietal sulcus (red) has connection only with parietooccipital sulcus (blue). There is no connection with cingulate sulcus (yellow). **(d)** Photograph of the medial surface of a right hemisphere demonstrating the subparietal sulcus (red) has connection with neither cingulate sulcus (yellow) nor parietooccipital sulcus (blue).

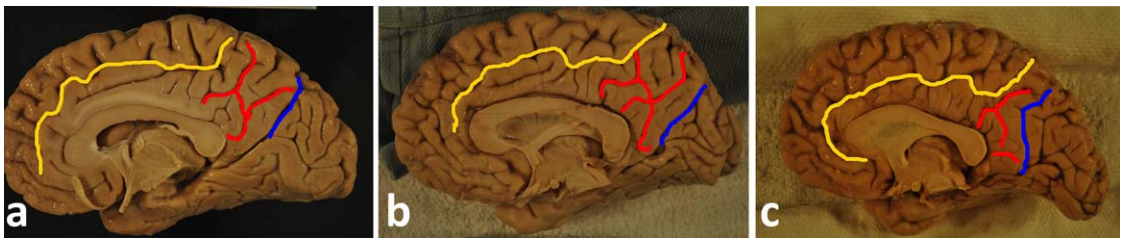

Fig. 4. Photographs demonstrating the direction of the posterior end of the subparietal sulcus: Inferiorly (anteriorly) directed, toward the splenium of the corpus callosum (**a**); posteriorly directed, toward the PS (**b**); posteriorly directed, toward the PS with a small free sulcus (**c**).

Double horizontal sulci pattern. Only three hemispheres (Fig. 2f) (5.4%) showed a double horizontal sulci pattern; two (7.1%) of them were left hemispheres, and one (3.6%) was right hemisphere.

In one of the left hemispheres (1.8%) the pattern cannot be classified due to complexity of the SS, and listed as undetermined.

SS Connections with the Cingulate Sulcus and PS

Connection with both the cingulate sulcus and PS. In five hemispheres (Fig. 3a) (8.9%), the SS was observed to be connected with both the cingulate sulcus and the PS. Of these five hemispheres, four (14.3%) contained a dual connection in the left and one dual connection (3.6%) was located in the right hemisphere.

Connection only with the cingulate sulcus. In 23 hemispheres (Fig. 3b) (41.1%), the SS was only connected with the cingulate sulcus anteriorly. Of these 23 hemispheres, 12 (42.9%) displayed this pattern in the left and 11 (39.3%) were located in the right hemispheres.

Connection only with the PS. In seven hemispheres (Fig. 3c) (12.5%), the SS was connected only with the PS posteriorly. Of these seven hemispheres, three (10.7%) were located in the left and four (14.3%) were located in the right hemispheres.

No connections with either. In 21 hemispheres (Fig. 3d) (37.5%), the SS was connected neither with the cingulate sulcus nor the PS. Of these 21 hemispheres, nine (32.1%) were located in the left, and 12 (42.9%) were located in the right hemisphere.

Numbers of Superior Branches of the SS Reaching the Superior Edge of the Precuneus

In 12 (21.4%) hemispheres [6 left (21.4%), 6 (21.4%) right], there were no upwardly directed branches crossing the superior margin of the hemisphere over the precuneus. Most of the hemispheres (n = 26, 46.4%) had one upwardly directed branch crossing the superior margin of the hemisphere over the precuneus. Of these 26 hemispheres, 16 (57.1%) were left hemispheres, and 10 (35.7%) were right hemispheres. Eighteen hemispheres (32.1%) showed two upwardly directed branches crossing the superior margin of the hemisphere over the precuneus. Of these 18 hemispheres, six (21.4%) were left hemispheres, and 12 (42.9%) were right hemispheres.

The Direction of the Posterior End of the SS

Inferiorly (anteriorly) directed, toward the splenium of the corpus callosum. In 29 (51.8%) (Fig. 4a) hemispheres, the posterior end of the SS was directed anteriorly towards the splenium of the corpus callosum. Of these 29 hemispheres, 11 (39.3%) were located in the left and 18 (64.3%) were located in the right hemisphere.

Posteriorly directed, toward the PS. In 25 (Fig. 4b) (44.6%) hemispheres, the posterior end of the SS was directed anteriorly towards the splenium of the corpus callosum. Of these 25 hemispheres, 16 (57.1%) were located in the left and 9 (32.1%) were located in the right hemisphere.

Posteriorly directed, toward the PS with a small free sulcus. Only two (Fig. 4c) (3.6%) hemispheres showed the posterior end of the SS directed posteriorly towards the PS with a small free sulcus. One of these two hemispheres was a left hemisphere and the other one was a right hemisphere.

The Number of the Side Branches of the SS

In 12 (21.4%) hemispheres [6 left (21.4%), and 6 (21.4%) right], there were no side branches observed. In 23 hemispheres (41.1%), the SS had one side branch. Of these 23 hemispheres, 12 (42.9%) were left hemispheres and 11 (39.3%) were right hemispheres. Two side branches of SS were observed in 15 hemispheres (26.8%). Of these 15 hemispheres, seven (25%) were left hemispheres and eight (28.6%) were right hemispheres. The SS of 6 (10.7%) hemispheres [3 left (10.7%), 3 (10.3%) right] showed three side branches.

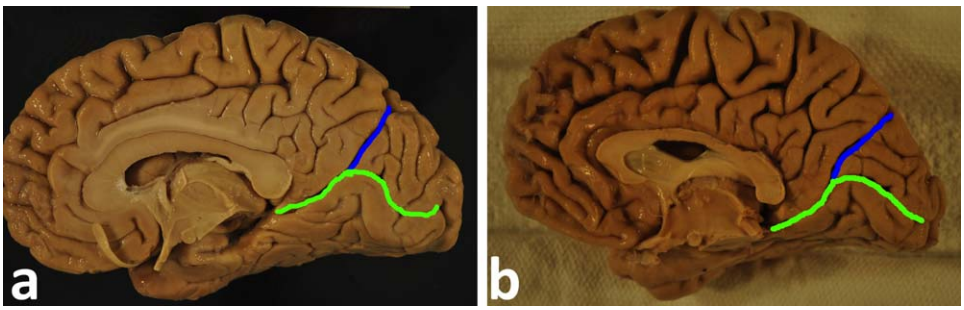

Fig. 5. Photographs demonstrating the parietooccipital sulcus (blue) origin (end-point) on the medial surface. The origin can be anterior to the first peak of the calcarine sulcus (green) (**a**); or at the first peak of the calcarine sulcus (**b**).

Parietooccipital Sulcus Origin (End-Point) on the Medial Surface

In 31 (55.4%) hemispheres [17 of these were left hemispheres (60.7%) and 14 was right hemispheres (50%)], the location of the end-point of the PS was located anterior to the first peak of the calcarine sulcus (Fig. 5a).

In the 25 (44.6%) hemispheres (11 of these were left hemispheres (39.3%) and 14 was right hemispheres (50%)) the location of the end-point of the PS was located at the first peak of the calcarine sulcus (Fig. 5b).

Parietooccipital Sulcus Extension Onto the Lateral Surface

The PS was observed to be extended to the lateral surface of 52 (92.9%) hemispheres. Only in three left hemispheres (10.7%) and one right hemisphere (3.6%), did the PS not extend to the lateral surface.

Parietooccipital Sulcus Patterns

Straight pattern. The straight pattern was observed in 30.4% (Figs. 1b and 6a) (n = 17) of all hemispheres, being the most common pattern of the PS. Ten (35.7%) of the left hemisphere showed the straight pattern, whereas 7 (25%) straight patterns were identified in the right hemispheres.

T- or Y-shape pattern. A T- or Y-shape pattern was observed in 28.6% (Fig. 6b) (n = 16) of all of the hemispheres. Eight (28.6%) of the left hemispheres and also 8 (28.6%) of the right hemispheres had a T- or Y-shape pattern.

Ramified to three branches with the inferior branch directed posteriorly. The PS was ramified to three branches with the inferior branch directed

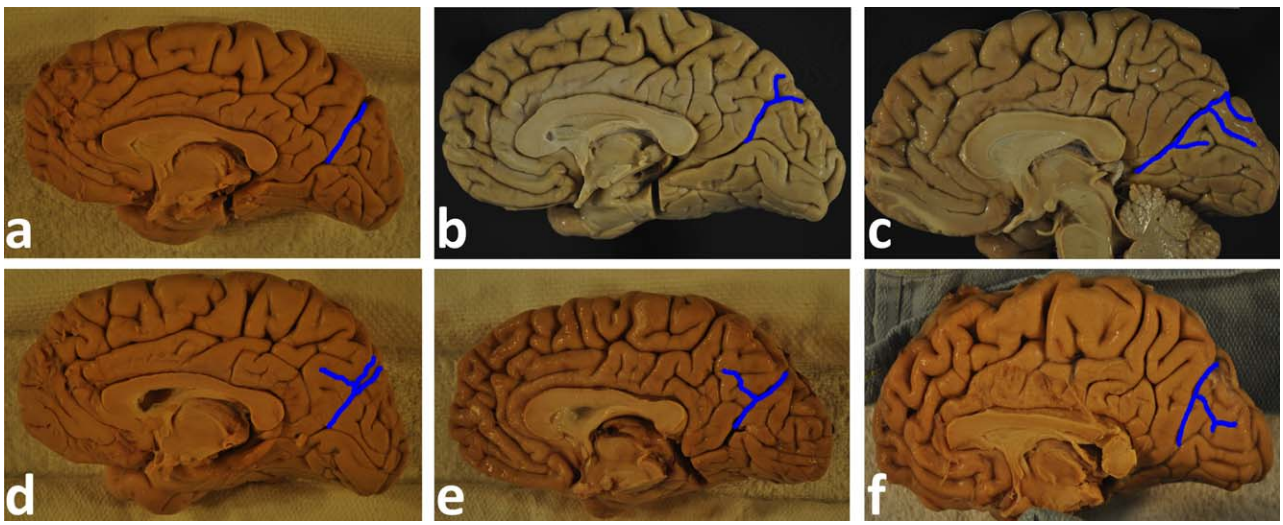

Fig. 6. Photographs demonstrating the parietooccipital sulcus patterns: straight (**a**); T- or Y-shape (**b**); ramified to three branches with inferior branch directed posteriorly (**c**); ramified to three branches with inferior branch directed anteriorly (**d**); one anteriorly directed large side branch present (**e**); one posteriorly directed large side branch present (**f**).

posteriorly in the 13 (23.2%) hemispheres (Fig. 6c). Of these 13 hemispheres, six (21.4%) were left and seven (25%) were right hemispheres.

Ramified to three branches with the inferior branch directed anteriorly. The PS (Fig. 6d) was ramified to three branches with inferior branch directed anteriorly in only one (1.8%) right hemisphere.

One anteriorly-directed large side branch present. In three (Fig. 6e) (5.4%) hemispheres [two left hemispheres (7.1%) and one right hemisphere (3.6%)] one anteriorly directed large side branch was presented.

One posteriorly-directed large side branch present. In six (Fig. 6f) (10.7%) hemispheres [two left hemispheres (7.1%) and four right hemispheres (14.3%)] one posteriorly directed large side branch was presented.

Distribution of the Side Branches of the PS

In the 32 (57.1%) no side branch was observed [16 of these hemispheres were left-sided (57.1%) and another 16 were right-sided (57.1%)]. In the 12 (21.4%) of the hemispheres an anteriorly directed side branch toward the precuneus was observed [6 of these hemispheres were left-sided (21.4%) and another 6 were right-sided (21.4%)]. In another 12 (21.4%) of the hemispheres an anteriorly directed side branch toward the isthmus of the cingulate gyrus was observed [6 of these hemispheres were left-sided (21.4%) and another 6 were right-sided (21.4%)].

All the data relevant to the SS and PS were summarized in Table 1.

DISCUSSION

Removal of mass lesions located deep in the brain is always a challenge for neurosurgeons. Microanatomical knowledge of the sulcal and fissural anatomy is essential for proper removal of such lesions (Yasargil, 1988). In order to correctly localize the pathology and its relationship with the eloquent areas, the anatomy of the sulci and gyri has to be clearly delineated. Comprehensive descriptions of the medial parietal lobe surface anatomy applicable to microneurosurgical interventions are limited and mostly based on a single study of 25 human brains by Ono et al. (1990).

Foville, in 1844, was the first to refer to the precuneus (Foville, 1844). The precuneus is limited anteriorly by the marginal ramus of the cingulate sulcus, posteriorly by the PS, and inferiorly by the SS. Although the precuneus itself may not frequently harbor a lesion, it is an important landmark for posterior interhemispheric approaches to the splenium of the corpus callosum, posterior cingulate gyrus, medial occipital lobes, and especially to the trigonal area (Yasargil, 1988). The significance of the SS and PS as landmarks for posterior interhemispheric approaches has been emphasized in the literature (Yasargil, 1988, 1996; Kawashima et al., 2006; Yasargil and Abdulrauf, 2008; Wang et al., 2010). As surgical approaches to this area have been rarely used, neurosurgeons may not necessarily be familiar with variations and terminology relevant to the medial parietal lobe. Although Ono et al. (1990), published a detailed anatomy of this region in a textbook, a more accessible additional study is still needed.

Both the SS and the PS reveal significant variations in their patterns and distribution (Ono et al., 1990). In this present study, we document that the most common pattern of the SS is the "H" pattern for both hemispheres. In Ono's study (Ono et al., 1990), the SS most commonly displayed the "H" pattern on the left, and the "split H" on the right hemispheres. Only few "split H" patterns (3.6% of all hemispheres) are identified in our study. Furthermore, "the triple upward branch pattern" is the second most common pattern of the SS in our series.

Rhoton (2002) described the SS as an indistinct posterior continuation of the cingulate sulcus distal to marginal ramus. In our series only 50% of the SS are anteriorly connected with cingulate sulcus and the remainder are not. Also, in 37% of our cases SS remains as a distinct sulcus without connection with either the cingulate sulcus or the PS.

Ono et al. found that a straight or a non-branching PS existed in 16 and 24% of the cases on the right and left respectively, while branching patterns predominated (Ono et al., 1990). In particular "T" or "Y" shape patterns were seen in 24% on both the right and left. Lastly the most common pattern was a three-branched PS, which was seen in 40% of cases on the right. By contrast our results reveal that the most common pattern on the right is "T" or "Y" shape pattern (28.6%) while on the left the most common pattern is the "straight pattern" (35.7%).

Cavanna and Trimble (2006) reported that the PS has a limited extension superiorly toward the vertex and that it did not reach the lateral surface of the cerebrum. They also observed that the inferior end of the PS terminated at the level of the superior bend of the calcarine sulcus, or slightly more anteriorly. Our study reveals that the inferior end of the PS terminates anteriorly to the first peak of the calcarine sulcus in 55.4% of all hemispheres, and at the first peak of the calcarine sulcus in 44.6% of hemispheres. Observations in the current study indicate that nearly all (92.9%) PS reach the lateral surface of the brain.

CONCLUSIONS

Our study further confirms complexities in patterns of both the SS and the PS and yet demonstrates that these sulci fall within an expected range of variations. Better knowledge of these variations will further help neurosurgeons to navigate easily during approaches involving the medial surface of the parietal lobe.

TABLE 1. The Patterns, Side Branches, and the Connections of the SS and PS

	Left hemisphere *n* (%)	Right hemisphere *n* (%)	Total *n* (%)
Subparietal sulcus patterns			
H pattern	12, (42.9%)	16, (57.1%)	28, (50%)
Split-H pattern	1, (3.6%)	1, (3.6%)	2, (3.6%)
Oblique pattern	0, (0%)	1, (3.6%)	1, (1.8%)
Single upward branch pattern	6, (21.4%)	4, 14.3%)	10, (17.9%)
Triple upward branch pattern	6, (21.4%)	5, (17.9%)	11, (19.6%)
Double horizontal sulci pattern	2, (7.1%)	1, (3.6%)	3, (5.4%)
Unidentified	1, (3.6%)	0, (0%)	1, (1.8%)
Subparietal sulcus connection with the cingulate and PS			
Connection with both	4, (14.3%)	1, (3.6%)	5, (8.9%)
Connection only with the cingulate sulcus	12, (42.9%)	11, (39.3%)	23, (41.1%)
Connection only with the PS	3, (10.7%)	4, (14.3%)	7, (12.5%)
No connection with either	9, (32.1%)	12, (42.9%)	21, (37.5%)
Numbers of the superiorly-directed branches of the SS			
0	6, (21.4%)	6, (21.4%)	12, (21.4%)
1	16, (57.1%)	10, (35.7%)	26, (46.4%)
2	6, (21.4%)	12, (42.9%)	18, (32.1%)
Direction of the posterior end of the SS			
Inferiorly (anteriorly)[a] directed, toward the splenium of the corpus callosum	11, (39.3%)	18, (64.3%)	29, (51.8%)
Posteriorly directed, toward the PS	16, (57.1%)	9, (32.1%)	25, (44.6%)
Posteriorly directed, toward the PS with a small free sulcus	1, (3.6%)	1, (3.6%)	2, (3.6%)
The number of the side branches of the SS			
0	6, (21,4%)	6, (21,4%)	12, (21.4%)
1	12, (42,9%)	11, (39.3%)	23, (41.1%)
2	7, (25%)	8, (28.6%)	15, (26.8%)
3	3, (10.7%)	3, (10.7%)	6, (10.7%)
Parietooccipital sulcus origin (end-point) on the medial surface			
Anterior to the first peak of the calcarine sulcus	17, (60.7%)	14, (50%)	31, (55.4%)
At the first peak of the calcarine sulcus	11, (39.3%)	14, (50%)	25, (44.6%)
Parietooccipital sulcus extension on to the lateral surface			
Yes	25, (89.3%)	27, (96.4%)	52, (92.9%)
No	3, (10.7%)	1, (3.6%)	4, (7.1%)
Parietooccipital sulcus patterns			
Straight pattern	10, (35.7%)	7, (25%)	17, (30.4%)
T- or Y-shape pattern	8, (28.6%)	8, (28.6%)	16, (28.6%)
Ramified to three branches with inferior branch directed posteriorly	6, (21.4%)	7, (25%)	13, (23.2%)
Ramified to three branches with inferior branch directed anteriorly	0, (0%)	1, (3.6%)	1, (1.8%)
One anteriorly-directed large side branch present	2, (7.1%)	1, (3.6%)	3, (5.4%)
One posteriorly-directed large side branch present	2, (7.1%)	4, (14.3%)	6, (10.7%)
Parietooccipital sulcus side branch distribution			
Directed toward the precuneus	6, (21.4%)	6, (21.4%)	12, (21.4%)
Directed toward the isthmus of the cingulate gyrus	6, (21.4%)	6, (21.4%)	12, (21.4%)
No side branches	16, (57.2%)	16, (57.2%)	32, (57.2%)

SS, subparietal sulcus; PS, parietooccipital sulcus.
[a]For better clarity we elected the term "inferior" rather than "anterior" as used by Ono.

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REFERENCES

Cavanna AE, Trimble MR. 2006. The precuneus: A review of its functional anatomy and behavioural correlates. Brain 129:564–583.

Eberstaller O. 1884. Zur Oberflachenanatomie der Grosshirn-hemispharen. Wien Med Blaeter 7:479–482.

Foville Al. 1844. Traité complet de l'anatomie, de la physiologie et de la pathologie du système nerveux cérébro-spinal. Paris: Masson et Cie.

Harkey HL, al-Mefty O, Haines DE, Smith RR. 1989. The surgical anatomy of the cerebral sulci. Neurosurgery 24:651–654.

Kawashima M, Li X, Rhoton AL Jr, Ulm AJ, Oka H, Fujii K. 2006. Surgical approaches to the atrium of the lateral ventricle: Microsurgical anatomy. Surg Neurol 65:436–445.

Nishikuni K, Ribas GC. 2013. Study of fetal and postnatal morphological development of the brain sulci. J Neurosurg Pediatr 11:1–11.

Ono M, Kubik S, Abernathey CD. 1990. Atlas of the cerebral sulci. Stuttgart: Thieme.

Paus T, Tomaiuolo F, Otaky N, MacDonald D, Petrides M, Atlas J, Morris R, Evans AC. 1996. Human cingulate and paracingulate sulci: Pattern, variability, asymmetry, and probabilistic map. Cereb Cortex 6:207–214.

Pia HW. 1986. Microsurgery of gliomas. Acta Neurochir 80:1–11.

Retzius G. 1896. Das Menschenhirn. Stockholm: Norstedt Soner.

Rhoton AL Jr. 2002. The cerebrum. Neurosurgery 51(4 Suppl):S1–S51.

Ribas GC, Yasuda A, Ribas EC, Nishikuni K, Rodrigues AJ Jr. 2006. Surgical anatomy of microneurosurgical sulcal key points. Neurosurgery 59(Suppl 2):ONS177–ONS210.

Wang S, Salma A, Ammirati M. 2010. Posterior interhemispheric transfalx transprecuneus approach to the atrium of the lateral ventricle: A cadaveric study. J Neurosurg 113:949–954.

Weinberg R. 1905. Die Gehirnform der Polen. Z Morphol Anthropol 8:123–214.

Williams PI, Warnick R. (eds.) 1986. Gray's anatomy. 36th Ed. Philedelphia: W.B. Saunders Company. p 988–989.

Yaşargil MG, Abdulrauf SI. 2008. Surgery of intraventricular tumors. Neurosurgery 62(Suppl 3):1029–1040.

Yaşargil MG, Cravens GF, Roth P. 1988. Surgical approaches to "inaccessible" brain tumors. Clin Neurosurg 34:42–110.

Yasargil MG, Kasdaglis K, Jain KK, Weber HP. 1976. Anatomical observations of the subarachnoid cisterns of the brain during surgery. J Neurosurg 44:298–302.

Yasargil MG. 1984. Microneurosurgery. Stuttgart: Georg Thieme, Vol. I.

Yasargil MG. 1994. Microneurosurgery. Stuttgart: Georg Thieme, Vol. IVa.

Yasargil MG. 1996. Microneurosurgery. Stuttgart: Georg Thieme, Vol. IVb.