Abhidha Shah
Atul Goel
Yoko Kato *Editors*

Functional Anatomy of the Brain: A View from the Surgeon's Eye

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ISBN 978-981-99-3411-9 ISBN 978-981-99-3412-6 (eBook)
https://doi.org/10.1007/978-981-99-3412-6

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

To my parents Harshad and Ila, Nalin uncle, Aditi and Manan for their constant love, support, understanding, and encouragement.

And

To Prof. Atul Goel for guiding and inspiring me and molding me into the neurosurgeon I am today.

—Abhidha Shah

Dedicated to the companionship, love, and affection of my wife Naina Goel.

—Atul Goel

Dedicated to Prof. Tetsuo Kanno.

—Yoko Kato

Foreword

It is a pleasure for me to write the foreword for the new book *Functional Anatomy of the Brain: A View from the Surgeon's Eye* co-edited by two highly experienced neurosurgeons—Prof. Goel and Prof. Kato.

The idea of the book is to present the general and functional anatomy, which is relevant for surgeries in complex brain regions. Each chapter is devoted to a particular brain area, presenting its structural organization and microsurgical anatomy, related to the most common surgical approaches. It is illustrated with multiple clearly described clinical examples. A special emphasis is placed on the organization of white matter/fiber tracks in the brain and its significance for planning and performing surgery. The reader is led step-by-step through the main steps of the operative approach. Multiple intraoperative photographs enhance the orientation and emphasize potential risks to critical anatomical structures.

A special highlight is the detailed and beautiful illustration of the structural organization of the brainstem and its relevance for surgeries in the area. Not only the nuclei but also all-important fiber tracts and functional systems are depicted in a practically oriented manner rendering it, as well as the whole book, as a very useful teaching manual.

The knowledge of the microanatomy of the brain is a prerequisite for operating complex brain tumors. However, the expanding tumor itself causes unpredictable changes of the normal anatomy and of the location and relation of the tumor to the important surrounding vessels, cranial nerves, or essential brain areas. This "pathological microanatomy" can only be appreciated at surgery under the operating microscope. The clinical experience cannot be supplemented for by studying cadaver anatomy.

My vast experience over the last three to four decades has shown me that there is enormous variability in the course of fiber tracts in individual patients. Additionally, the pathological lesion causes additional changes by either compression or infiltration of the adjacent brain. Slowly growing tumors cause unpredictable functional reorganization of the cortical areas and their connecting fiber tracts. The utilization of brain mapping techniques allows us to demonstrate the functional organization of the brain in each individual case before surgery. As described and nicely illustrated in the current book, this information can be implemented preoperatively for defining the surgical strategy and selecting the safest operative approach. Importantly, the application of functional neuronavigation, which integrates the data from the fMRI and DTI-based tractography, allows us to utilize this information during surgery. Intraoperative MRI allows for the updating of this functional information in order to overcome the effect of brain shift. I hope that future technological advances will allow acquiring more reliable and detailed information before and during surgery, which will further decrease operative risks.

With our increasing understanding of the brain's structure and organization, it becomes obvious that every attempt should be made to preserve all white matter tracts in order to avoid neurological or psychological changes after surgery. The risks of such potential postoperative changes should be considered, but always in relation to the oncological goal of the surgery. The use of transverse callosotomy, for example, allows avoiding larger disruption of the interhemispheric connecting fibers. It could be successfully applied in case of certain small tumors, but for the successful and safe removal of larger ventricular tumors a longitudinal callosotomy is certainly required.

I am confident that the book is a good contribution to the neurosurgical literature. I congratulate the authors and hope very much that the book will help many young neurosurgeons to understand the complex anatomy of the brain and the principles of surgery of complex brain tumors.

INI, Hanover, GmbH Madjid Samii

Preface

Everything we do, every thought we've ever had, is produced by the human brain. But exactly how it operates remains one of the biggest unsolved mysteries, and it seems the more we probe its secrets, the more surprises we find.
—Neil deGrasse Tyson

The brain is the most magnificent and enigmatic organ of the body and that makes neurosurgery one of the most technically challenging and demanding disciplines of medicine.

For a long time the field of neurosurgery was considered as a "no man's land" as the surgical outcomes were often worse than the natural history of the disease itself. The last decade has witnessed the goal of neurosurgery changing from just "saving lives" to achieving a better quality of life that enables the patient to go back to his routine life and occupation.

The human neural network consists of "nodes" (cortical areas) connected by a series of "edges or links" (subcortical network) to create the most fascinating grid of motor, sensory, autonomic, and emotional function. Understanding this neural circuitry is the key to a successful brain surgery. Mastering the three-dimensional architecture of the brain anatomy is the building block to become an accomplished neurosurgeon.

The human brain is an archetypal complex system. This book aims to correlate the exquisite anatomy with the functions of the brain and thus help in building a map of the surgical arena to result in a surgical victory.

Technology has rapidly paved its way into neurosurgery. A modern-day neurosurgical operation theater may very well resemble a space station. A "brain suite" has its microscope, neuronavigation station, CUSA, intraoperative ultrasound, neurophysiological monitoring system, endoscope, and intraoperative CT/MRI. A hybrid brain suite allows for intraoperative cerebral angiography while performing vascular neurosurgery. The neurosurgeon is at the center of this machinery and dictates the use of each. But all this clutter of gadgetry cannot replace exquisite neurosurgical technique. Just as the skill of a pilot is measured by his manual flying skills where the maneuvers are carried out by analysis of raw information obtained from airspeed, altitude, weather, and heading without use of any modern technology, the skill of a neurosurgeon is measured by his neurosurgical technique. Mastery of the technical skills of neurosurgery requires great passion and practice, an amalgamation of heart, mind, and soul till perfection is achieved. This skill defines the caliber of a neurosurgeon much like an artist in any field. Without this mastery of technique no fancy gadgetry will help you perform good neurosurgery.

All in all neurosurgery is an art. Modern-day neurosurgery has advanced to make brain surgery safe. As neurosurgeons we have great responsibility but also have the unique pleasure of seeing a patient become conscious again or walking again or talking again after a good neurosurgical procedure has been performed. There can be no greater joy than this.

> *Only the neurosurgeon dares to improve upon five billion years of evolution in a few hours.*
> *The human brain. A trillion nerve cells storing electrical patterns more numerous than the water molecules of the world's oceans. The soul's tapestry lies woven in the brain's nerve threads. Delicate, inviolate, the brain floats serenely in a bone vault like the crown jewel of biology. What motivated the vast leap in intellectual horse-power between chimp and man? Between tree dweller and moon walker? Is the brain a gift from God, or simply the jackpot of a trillion rolls of DNA dice?*
> *—Frank Vertosick Jr.*

Mumbai, India Atul Goel

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About the Editors

Abhidha Shah is an Associate Professor at the neurosurgery department at King Edward Memorial Hospital and Seth G.S. Medical College. She serves as an associate editor of "Journal of Craniovertebral Junction and Spine" and the "International Journal of Neuroscience." She has more than 160 peer-reviewed international and national publications and has written 20 book chapters. She has been awarded the Vesalius award and the Women in Neurosurgery—Greg Wilkins—Barrick Chair—Visiting International Surgeon award by the American Association of Neurological Surgeons. She has a particular interest in the anatomy of the white fibers of the brain and intra-axial surgery related to anatomy and function. She has been awarded the Indian Society of Neuro-oncology President's award for her clinical research on this subject. She is a member of the International Academy of Neurosurgical Anatomy. She is also on the World Federation of Neurosurgical Societies (WFNS) committee of Neurosurgical Anatomy. Currently she serves as an executive council member of the Neurological Society of India and is the Chair of the Women in Neurosciences section the society. She is also the Secretary of the Women in Neurosurgery Section of the Asian Congress of Neurological Surgeons.

Atul Goel is the Chairman of the neurosurgery department at the Lilavati Hospital and Research Centre. He is Professor Emeritus at the King Edward Memorial Hospital and Seth G.S. Medical College and K.E.M Hospital. Prof. Goel has written over 750 articles finding space in Pubmed. Prof. Goel has vast surgical experience on several complex issues. He has written two books published by the leading medical books publisher (Churchill Livingstone in 1997 and Thieme publishers in 2011). He has published over 180 articles presenting new (small and big) surgical techniques, more than 30 articles introducing philosophical and spiritual issues about neurosurgery. He is currently serving as the president of the craniovertebral junction and spine society. He has been awarded the eminent medical teacher, Dr. B.C. Roy National Award, Dandy medal for distinguished neurosurgery services-2018, Outstanding contribution award—Chinese society of Neurosurgery-2019, and International Ambassador award by Congress of Neurological Surgeons, San Francisco 2019. He has been conferred Lifetime Achievement Awards by the Neurospinal Surgeons Association (NSSA) and the Delhi Spine Society. He is a board member of the prestigious International Rhoton Society. He has many US and Indian patents to his name.

Yoko Kato is currently working as Chairman of the neurosurgery department at Fujita Health University Banbuntane Hotokukai Hospital, Japan, where she also holds the position of assistant director of the University. Prof. Kato has received several awards, like the WFNS Medal of Honor award in 2019 and the Honorary Fellowship award in the American College of Surgeons in San Francisco in 2019. She is the editor-in-chief of "Asian Journal of Neurosurgery" and has more than 300 international peer-reviewed publications. She has written numerous chapters in primary neurosurgical textbooks. She is the President of the Asian Congress of Neurological Surgeons.

Anatomy Guided Microneurosurgery of Cerebral Lesions

Guilherme Carvalhal Ribas
and Eduardo Carvalhal Ribas

1 Introduction

The description of a motor language center by Broca [1, 2] and of the motor strip by H. Jackson [2–4] gave rise along the second half of the nineteenth century to the study and description of cranial-cerebral relationships in order to make craniotomies more clinically guided. Broca was the pioneer of these studies [5, 6] having related the eloquent and the main brain gyri and sulci more particularly with the cranial sutures and with the craniometric points he also had described [6], and was soon followed by many other authors [7–11].

More recently, the advent of microneurosurgery started with Yaşargil along the 1970s [12, 13] turned the brain sulci in the major surgical landmarks of the cerebral surface and also made them possible corridors for microneurosurgical procedures [14, 15].

Parallel to the development of microneurosurgery the use of the microscope disclosed a new microanatomical surgical universe which was studied and revealed particularly by Yaşargil himself [13, 15–19] and by Rhoton and his fellows which publications were recently put together in a unique book [20], and it is interesting to point out that the important chapter of cranial-cerebral relationships has not been often revisited along these last four decades. Recent textbooks' mentions of these anatomical relationships are usually very brief and pertinent only to classic descriptions [21–23], what motivated us to restudy this issue in the light of more recent microanatomic knowledge.

Although easily identifiable in standard magnetic resonance images, the brain sulci are usually difficult to be recognized in neurosurgical procedures not only because they are covered by the arachnoid membrane and frequently also by veins, but mainly because most of them are usually interrupted and have diverse anatomical variations [24].

Nevertheless, as already noticed by Broca [5, 6, 25], some specific points of the main brain sulci as their extremities and some gyral sites that underlie particularly prominent cranial points do have a more constant anatomy and, hence, more constant cranial-cerebral relationships. Beyond

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A. Shah et al. (eds.), *Functional Anatomy of the Brain: A View from the Surgeon's Eye*,
https://doi.org/10.1007/978-981-99-3412-6_1

the classic sulcal points originally described by Paul Broca and others we also studied other strategic key points like the meeting points of important sulci [26–30], and the regular neural and cranial-cerebral relationships of these specific anatomical points warrant these sites to be considered consistent microneurosurgical sulcal and cortical key-points [28–30]. Together with their corresponding cranial points they constitute a neurosurgical anatomic framework that can help in the understanding of the localization of cortical and subcortical lesions, in the placement of their required craniotomies, and to ease the initial transoperative identification of their related brain sulci and gyri.

According to our findings, the sulcal key points described along this text can be intraoperatively identified within an interval always smaller than 2 cm in relation to their corresponding cranial points, aided by the fact that the sulcal key points are usually visually characterized by a certain degree of enlargement of the subarachnoid space since they generally correspond to an intersection of two sulci. The surgeon's previous knowledge of the usual shape and most frequent anatomic variations of the main brain sulci helps to corroborate the identification of these sulci, and their key points' subaracnoid enlargements favor their initial microsurgical dissections.

Nowadays we fortunately have technology [31] to aid intraoperative localization for neurosurgeons, but unfortunately these extraordinary tools are not homogeneously available throughout our heterogeneous world, and, above all, of course technology should not substitute the anatomic tridimensional knowledge every neurosurgeon should acquire and should continuously develop along his or her practice [30].

On the other hand, it is important to emphasize that the anatomic identification of any eloquent cortical area, even when confirmed by any localizing imaging system, cannot safely substitute the current aid of transoperative neurophysiological testing due to common anatomic functional variations and their possible displacements and/or involvement by the existence of underlying pathology.

The following text is all based on our neurosurgical observations and laboratory findings that were published in four different main articles [24, 28–30], summarized in an important book chapter [32], and more extensively presented and discussed in a whole book that was published in 2018 [26].

Given the cranial-cerebral relationships scope of this chapter, its discussion of brain anatomy features is practically restricted to the main aspects of the brain superolateral surface. For further cranial-cerebral' anatomical details please consult the above references.

For practical purposes, while the anatomy of the brain sulci and gyri is presented here along the text and illustrations, the sulcal and gyral key-points and then cranial relationships are presented and detailed mainly through illustrations and legends.

2 General Features of the Brain Sulci and Gyri Architecture

It is interesting that the general organization of the brain gyri was understood as having a chaotic disposal for many centuries.

Achille Louis Foville depicted the cortical surface properly about 180 years ago [33, 34], and it was only about 160 years ago that Louis Gratiolet, studying comparative anatomy with his teacher Francois Lauret, perceived that the human brain does have an organized arrangement [24, 35, 36] (Figs. 1, 2 and 3).

In order to understand their organization we have initially to remember that the brain sulci were developed along evolution through an infolding process [37], which also takes place along our embryological and fetal developments, and which increases the human brain surface threefold. The generated area of approximately 2200 cm^2 [38] ends up with only one-third exposed and with the other two-thirds buried inside the intrasulcal spaces [39].

Given this infolding process, and since the arachnoid envelopes the whole brain, the sulci are extensions of the subaracnoid space and they have to be understood as anatomical concepts, and not as well defined spaces or compartments. While a few sulci are evident and frequently continuous as the superior frontal and the supe-

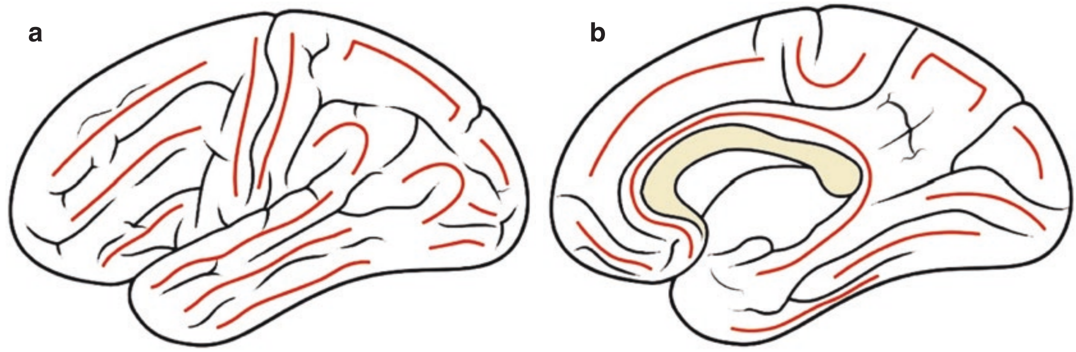

Fig. 1 Basic organization of the brain gyri. (**a**) superolateral surface and (**b**) medial and basal surfaces. Red lines indicate the usual arrangement of the main brain gyri, and the dark lines indicate the usual arrangement of the main brain sulci. (Adapted from [24])

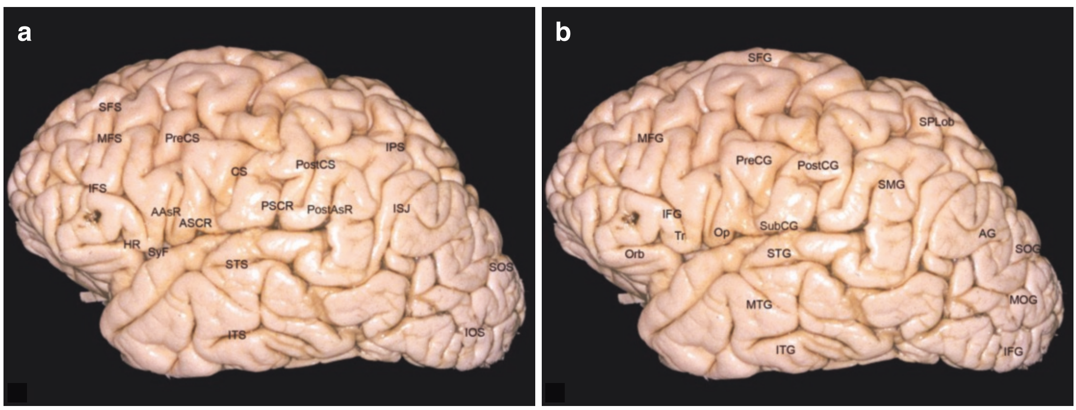

Fig. 2 The main brain sulci (**a**) and gyri (**b**) of the superolateral surface of the brain. *AAsR* Anterior Ascending Ramus, *AG* Angular Gyrus, *ASCR* Anterior Subcentral Ramus of Sylvian Fissure, *CS* Central Sulcus, *HR* Horizontal Ramus, *IFG* Inferior Frontal Gyrus, *IFS* Inferior Frontal Sulcus, *IOS* Inferior Occipital Sulcus, *IPS* Intraparietal Sulcus, *ISJ* Intermediary Sulcus of Jensen, *ITG* Inferior Temporal Gyrus, *ITS* Inferior Temporal Sulcus, *MFG* Middle Frontal Gyrus, *MFS* Middle Frontal Sulcus, *MOG* Middle Occipital Gyrus, *MTG* Middle Temporal Gyrus, *Op* Opercular Part of Inferior Frontal Gyrus, *Orb* Orbital Part of Inferior Frontal Gyrus, *PostAsR* Posterior Ascending Ramus, *PostCG* Postcentral Gyrus, *PostCS* Postcentral Sulcus, *PreCG* Precentral Gyrus, *PreCS* Precentral Sulcus, *PSCR* Posterior Subcentral Ramus of Sylvian Fissure, *SFG* Superior Frontal Gyrus, *SFS* Superior Frontal Sulcus, *SMG* Supramarginal Gyrus, *SOG* Superior Occipital Gyrus, *SOS* Superior Occipital Sulcus, *SPLob* Superior Parietal Lobule, *STG* Superior Temporal Gyrus, *STS* Superior Temporal Sulcus, *SubCG* Subcentral Gyrus, *SyF* Lateral or Sylvian Fissure, *Tr* Triangular Part of Inferior Frontal Gyrus. (Adapted from [24])

rior temporal sulci for example, most of the sulci are usually interrupted as the inferior frontal and inferior temporal for example, and it is the sum of their segments that constitute each of them.

The sulci can then be long or short, continuous or interrupted, straight or with different configurations. When always deep, evident and anatomically constant, they are also referred to as fissures by Broca [6, 24, 35, 36]. The continuous cortical sulci are the lateral or Sylvian Fissure, callosal, calcarine, parieto-occipital, collateral, the central sulcus generally, and frequently the superior frontal and the superior temporal sulci [24, 40].

The main sulci have approximate depths ranging from 1 to 3 cm, and their walls harbor small

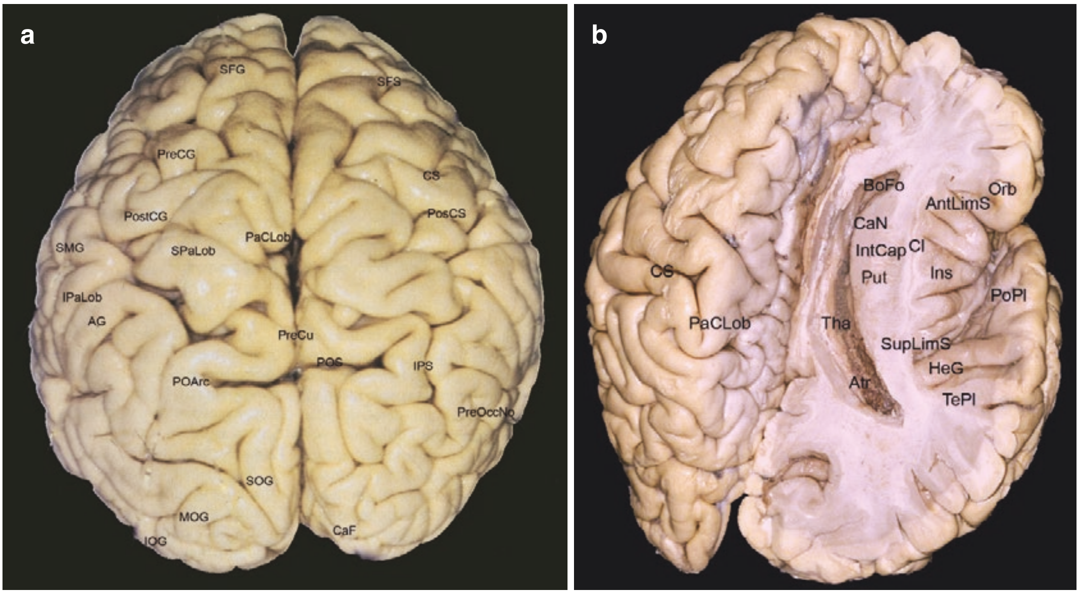

Fig. 3 (**a**) Superior view of the cerebral hemispheres, (**b**) the temporal opercular surface, insula, and the central core of the brain. *AG* Angular Gyrus, *AntLimS* Anterior Limiting Sulcus of insula, *Atr* Atrium of Lateral Ventricle, *BoFo* Body of Fornix, *CaF* Calcarine Fissure, *CaN* Caudate Nucleus, *Cl* Claustrum, *CS* Central Sulcus, *HeG* Heschl's Gyrus, *Ins* Insula, *IntCaps* Internal Capsule fibers, *IOG* Inferior Occipital Gyrus; *IPaLob* Inferior Parietal Lobule, *IPS* Intraparietal Sulcus, *MOG* Middle Occipital Gyrus, *Orb* Orbital part of Inferior Frontal Gyrus, *PaCLob* Paracentral Lobule, *POArc* Parieto-Occipital Arch, *PoPl* Polar Plane of the opercular temporal surface, *POS* Parieto-Occipital Sulcus seen on the superolateral surface, which corresponds to the Parieto-Occipital Incisures within the Parieto-Occipital Arch, *PosCS* Postcentral Sulcus, *PostCG* Postcentral Gyrus, *PreCG* Precentral Gyrus, *PreCu* Precuneus, *PreOccNo* Pre-Occipital Notch, *Put* Putamen, *SFG* Superior Frontal Gyrus, *SFS* Superior Frontal Sulcus, *SMG* Supramarginal Gyrus, *SOG* Superior Occipital Gyrus, *SPaLob* Superior Parietal Lobule, *SupLimS* Superior Limiting Sulcus of Insula, *TePl* Temporal Plane, *Th* Thalamus. (Adapted from [24])

gyri that face and adapt to each other which are generically designated as transverse gyri. The sulci that separate the transverse intrasulcal gyri vary in length and depth and at the surface of the brain they become visible as incisures.

It is noteworthy that the timing of the embryological development of the sulci and their degree of variability [41, 42] define a true morphological hierarchy at the top of which are the fissures and the main sulci. It is equally notable that this structural hierarchy is directly correlated with the functional importance of the areas to which the sulci are related, with the more anatomically constant sulci being those that are topographically related to areas that are more specialized [43, 44].

Due to their frequent variations and connections, the nomenclature of sulci varies among different authors according to their interpretations and designations [11, 24, 40, 45], but the current neurosurgical literature widely adopts the nomenclature proposed by Ono and Yaşargil [13, 15, 17, 40]. For their better understanding, it is important to emphasize that the sulci can vary in size and shape from person to person and these differences can be identified not only among individuals but also between the two hemispheres in the same individual, and, as already mentioned, they should then be understood as concepts and not as well defined spaces or compartments.

Also given the original infolding process the cortical surface is continuous along the sulci depths and around the sulci interruptions and extremities, and the brain gyri constitute then a real continuum which present as a serpentine configuration on the cerebral surface. For this reason the brain gyri, just as the brain sulci,

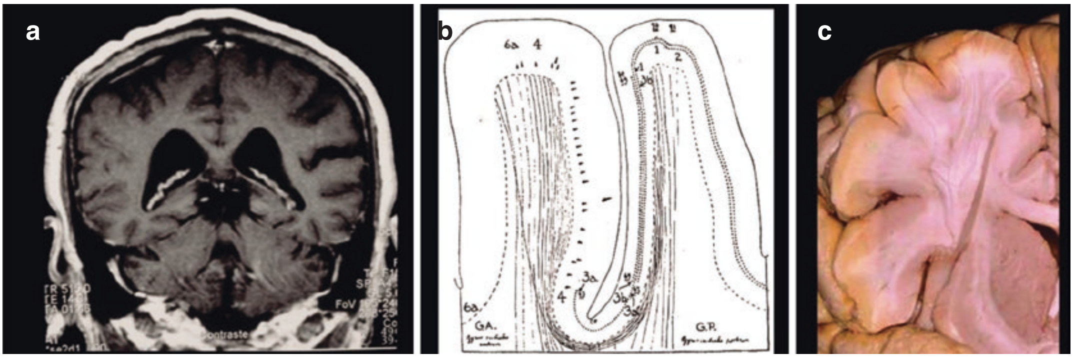

Fig. 4 (**a**) MRI coronal image showing the main sulci of the superolateral and basal brain surfaces point to the nearest ventricular cavity, the sulci of the medial surface are parallel to the corpus callosum; (**b**) classical sketch by Vogt C, Vogt O, 1919, 1928, and (**c**) cadaveric specimen, showing that while the projection fibers arise from the crest of the gyri, the bottom of the sulci are related to U-fibers

should be understood as arbitrary regions, as concepts, and not as well defined anatomical structures [24]. The term convolution usually refers to an anatomic well defined part of a gyrus. The well known orbital, triangular and opercular parts or convolutions together constitute the concept of inferior frontal gyris.

As already mentioned, despite their anatomical variations, the brain gyri do have a basic arrangement (Figs. 1, 2 and 3).

The original infolding process also implies in two important features of surgical interest: one is that all the main sulci of the superolateral and of the basal surfaces of the brain are pointing towards the nearest ventricular cavity, while the sulci of the medial surface are parallel to and dependent on the development of the corpus callosum (Fig. 4a). The other important feature of surgical interest is that while the projection fibers arise from the crest of the gyri, the depths of the sulci are exclusively related with U fibers (Fig. 4b, c). So, a transsulcal approach theoretically spares more projection fibers by putting them apart.

3 The Superolateral Brain Surface and its Sulcal Key-Points

While the cisternal and the intraventricular lesions are usually approached through standard craniotomies and microneurosurgical transfissural routes, the cortical-subcortical and the deep cerebral lesions require initially the understanding of their anatomical localization for the selection of their proper craniotomy placements and of their precise transsulcal, subpial or transgyral approaches (Fig. 5). For the correct approach of these lesions, as well for extrinsic convexity lesions, the understanding and identification of the brain sulci and gyri are mandatory and the framework provided by sulcal key-points can be of significant help (Figs. 6a, b).

In surgery, the only sulcus that can be securely identified is the Sylvian Fissure (SyF) and if we look along the SyF we can practically always identify a small area of a variable enlargement of the subaracnoid space, which corresponds to the Anterior Sylvian Point (ASyP) (Figs. 2, 6 and 7).

The ASyP divides the lateral or SyF in two parts: the anterior, sphenoidal or stem of the SyF, and the lateral or posterior part of the SyF.

From the ASyP always arise two Sylvian rami: the Anterior Ascending Ramus (AAsR) and the Horizontal Ramus (HR) which delineate the Triangular Part (TrP) of the Inferior Frontal Gyrus (IFG), which always harbors inside a small branch from the Inferior Frontal Sulcus (IFS) which comes from superior and anterior to inferior and posterior [28]). Anteriorly to the Triangular Part (TrP) there is the Orbital Part (OrbP), and posteriorly to it there is the Opercular Part (OpP), which is, in our opinion, the most constant U-shaped convolution of the human

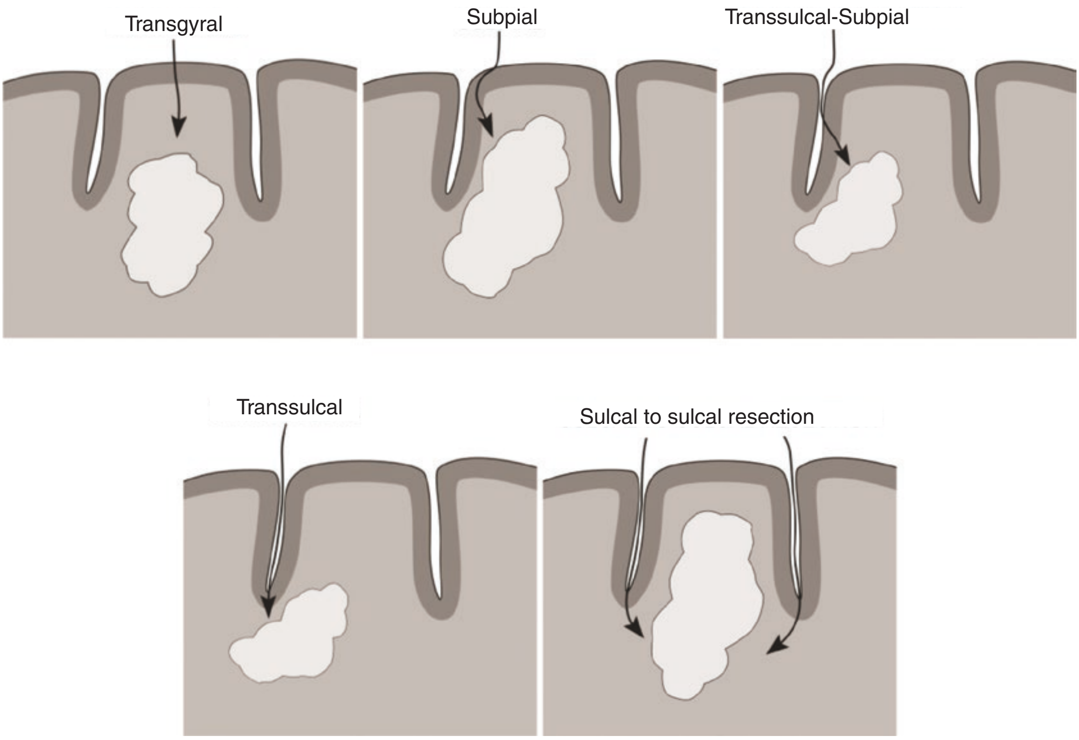

Fig. 5 Possible transcerebral microneurosurgical routes

brain and which always harbor the inferior part of the Precentral Sulcus (PreCS). We usually refer to the opercular part or convolution (OpP) as "the beatiful U".

The ASyP corresponds to an enlargement of the subaracnoid space of the SyF since the Triangular Part (TrP) is usually more retracted within the IFG. The ASyP lies then always at the inferior aspect of the Pars Triangularis (TrP), and in the anterior and basal aspect of the Opercular Part (OpP).

The Orbital, Triangular and Opercular Parts (OrbP, TrP, OpP) together constitute the concept of Inferior Frontal Gyrus (IFG). Its connection with the Precentral Gyrus (PreCG) corresponds to the posterior and ascending half of the U-shaped Opercular Part (OpP) which runs over the Anterior Subcentral Ramus (ASCR).

As already mentioned, the Inferior Frontal Sulcus (IFS) that separates the Inferior Frontal Gyrus (IFG) from the Middle Frontal Gyrus (MFG) is usually an interrupted sulcus formed by two, three or four segments, with the most posterior joining the Precentral Sulcus (PreCS). The so-called Ventral Premotor Area (VPreMA) is roughly located at this level within the Precentral Gyrus (PreCG) (Fig. 2).

The Fronto-Opercular Key Points and their corresponding cranial sites are shown in Fig. 7, and an example of their actual surgical application is shown in Fig. 8.

The Middle Frontal Gyrus (MFG) is the largest of the frontal gyri, and is posteriorly connected to the Precentral Gyrus (PreCG) through a superficial and prominent root responsible by a marked interruption of the Precentral Sulcus (PreCS). The so-called Dorsal Premotor Area (DPreMArea) corresponds roughly to the posterior aspect of the Middle Frontal Gyrus (MFG) (Fig. 2).

The Superior Frontal Gyrus (SFG) is posteriorly connected to the Precentral Gyrus (PreCG) at least through one fold which usually runs medially, already along the Interhemisperic Fissure (IHF). Anteriorly and inferiorly the SFG is continuous with the Rectus Gyrus (RG) already within the orbital frontal brain surface (Fig. 2).

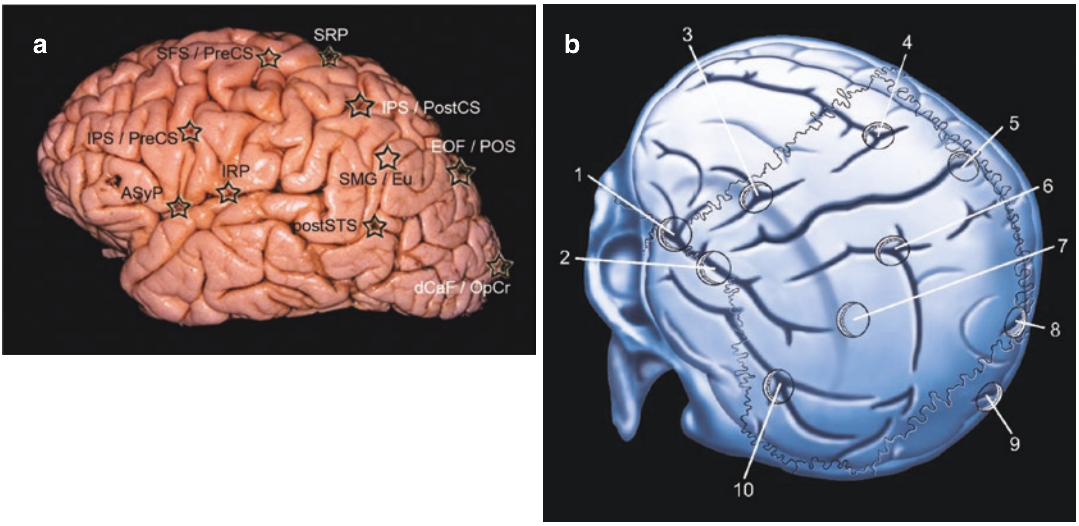

Fig. 6 (**a**) Microneurosurgical Sulcal/Cortical Key Points. The Microneurosurgical Key Points of the brain surface are constituted by real intersections between adjacent sulci or by their prolongations and by gyral and sulcal points located underneath prominent skull points such as the Euryon (center of the parietal tuterosity) and the Opisthocranion (most prominent occipital point). Note that the sulci meeting points are usually characterized by an enlargement of the subarachnoid space. *Eu* Euryon, *OpCr* Opisthocranion, *ASyP* Anterior Sylvian Point, *dCaF/OpCr* Distal Calcarine Fissure Point, underneath the Opisthocranion, *EOF/POS* External Occipital Fissure Medial Point, equivalent to the most superior of the Parieto-Occipital Sulcus in the medial surface of the brain, *IFS/PreCS* Inferior Frontal Sulcus and Precentral Sulcus meeting point, *IPS/PostCS* Intraparietal Sulcus and Postcentral Sulcus transitional or meeting point, *IRP* Inferior Rolandic Point, *postSTS* Superior Temporal Sulcus Posterior segment and extremity, *SFS/PreCS* Superior Frontal Sulcus and Precentral Sulcus meeting pont, *SMG/Eu* Superior aspect of the Supramarginal Gyrus disposed underneath the Euryon, *SRP* Superior Rolandic Point. (**b**) The main Sulcal and Gyral Key-Points and their cranial relationships: (1) the Anterior Sylvian Point (ASyP) lies underneath the most anterior portion of the Squamous suture, (2) the Inferior Rolandic Point (IRP) underneath the most superior portion of the Squamous suture, (3) the intersection of the Inferior Frontal Sulcus (IFS), or of its posterior prolongation, with the Precentral Sulcus (PreCS), lies just posteriorly to the Stephanion (St), craniometric point that corresponds to the intersection of the Superior Temporal Line (STL) with the Coronal Suture (CoSut), (4) the intersection of the Superior Frontal Sulcus (SFS), or of its posterior prolongation, with the Precentral Sulcus (PreCS), lies underneath the cranial point located 1.5 cm posteriorly to the Coronal Suture (CoSut) and 3 cm lateral to the sagittal suture, (5) the Superior Rolandic Point (SRP) lies underneath the cranial point located 5 cm posterior to the Bregma (Br), (6) the intersection of the Intraparietal Sulcus (IPS), or of its anterior prolongation, with the Postcentral Sulcus (PostCS), lies underneath the cranial point located 6 cm anterior to the Lambda (La) and 5 cm lateral to the Sagittal Suture (SagSut), (7) the Euryon (Eu), craniometric point that corresponds to the center of the parietal tuberosity, is located over the superior aspect of the Supramarginal Gyrus (SMG), (8) the superior point of the Parieto-Occipital Sulcus (POS) lies underneath the angle between each Lambdoid (LaSut) and the Sagittal Suture (SagSut), (9) the Opisthocranion (OpCr), that corresponds to the most prominent point of the occipital bossa, is located just superiorly to the Calcarine Fissure Distal Point (dCaF), over the Cuneus (CuG) most prominent aspect, and (10) the Posterior Point of the Superior Temporal Sulcus (STS) lies underneath the cranial point located 3 cm superiorly to the Parietomastoid (PaMaSut) and Squamous (SqSut) sutures meeting point. Measurements with an error <2 cm; adapted from [26–30]

The important Suplementary Motor Area (SMA) corresponds to a not well defined area mostly within the posterior and medial aspect of the SFG, radiologically defined as located between the two lines originated respectively at the anterior and posterior commissures and perpendicular to the line that join these two commissures.

The Superior Frontal Sulcus (SFS) which separates the Superior and the Middle Frontal Gyri (SFG, MFG) is usually a very evident and deep sulcus, parallel to the superomedial margin of the cerebral hemisphere, frequently continuous [40] or with a long continuous segment, and ends posteriorly usually joining the Precentral Sulcus (PreCS) and encroaching the Precentral Gyrus

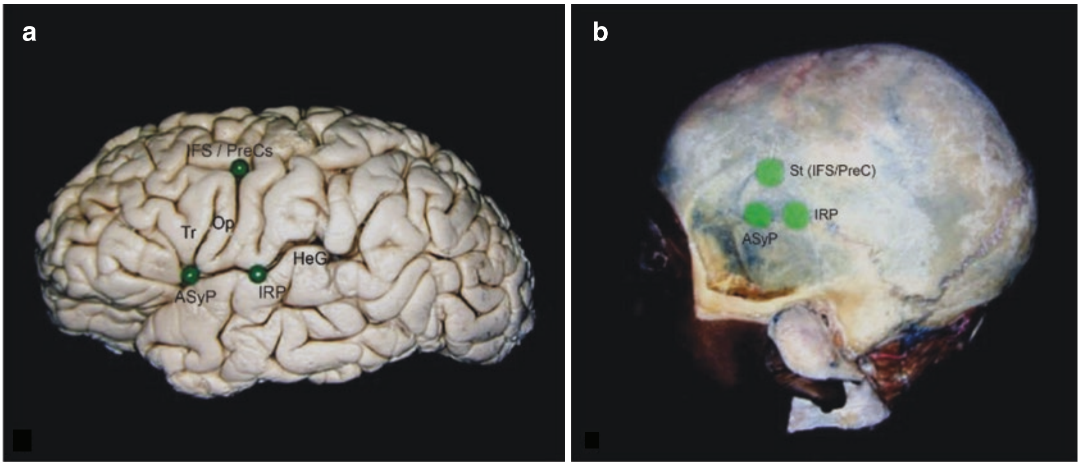

Fig. 7 (**a**) Fronto-Opercular Key Points and (**b**) their corresponding cranial sites: (1) the Anterior Sylvian Point (ASyP) is characterized by enlargement of the Sylvian fissure inferior to the Triangular Part (Tr) and anterior to the Opercular Part (Op) of the Inferior Frontal Gyrus (IFG), and lies underneath the most anterior aspect of the Squamous Suture (SqSut), just posterior to the pterion; (2) the Inferior Rolandic Point (IRP) is located along the Sylvian Fissure (SyF) 2–3 cm posteriorly to the ASyP, just anteriorly to Heschl's Gyrus (HeG), and lies underneath the highest aspect of the Squamous Suture (SqSut), which also corresponds to the intersection of this suture with a vertical line originating at the preauricular depression, about 4 cm high in adults; and (3) the inferior frontal and precentral sulci meeting point (IFS/PreCS), which indicates the superior aspect of the opercular part (Op) of the IFS (up to 3 cm high from the Sylvian fissure), which corresponds to the face motor activation/ventral premotor area (VPM), and which lies underneath the craniometric point known as the Stephanion (St) which corresponds to the site of intersection of the coronal suture with the superior temporal line [28, 30]. *ASyP* Anterior Sylvian Point, *HeG* Heschl's Gyrus, *IFG* Inferior Frontal Gyrus, *IFS/PreCS* Inferior Frontal and Precentral Sulci meeting point, *IFS* Inferior Frontal Sulcus, *IRP* Inferior Rolandic Point, *Op* Opercular Part, *St* Stephanion (meeting point of the coronal suture and superior temporal line), *Tr* Triangular Part of inferior frontal gyrus

(PreCG) exactly at the level of the Omega region which corresponds to the hand motor cortical area [46, 47] (Figs. 2 and 9).

The Superior Frontal Gyrus (SFG) is frequently divided by a secondary and shallow sulcus parallel to Superior Frontal Sulcus (SFS), known as the Medial Frontal Sulcus (MeFS).

The Superior Frontal and Precentral Sulci Meeting Point is then an important sulcal Key Point, located just anteriorly to the Omega region. Its corresponding cranial site is shown in Fig. 9, and its surgical application can be seen in the case shown in Fig. 10.

Anteriorly the three frontal gyri are delineated by the appropriately named Frontomarginal Sulcus (FMaS) which separates the superolateral from the orbital frontal brain surface, and which is more frequently interrupted [45, 48].

Along the Sylvian Fissure (SyF), posteriorly to the anatomically well defined Opercular Part (OpP), there are the Anterior and the Posterior Subcentral Rami (ASCR, PSCR) of the Sylvian Fissure (SyF) which delineate the Subcentral Gyrus (SubCG) that connects inferiorly the oblique Precentral and Postcentral Gyri (PreCG, PostCG) (Fig. 2).

The Precentral (PreCG) and the Postcentral (PostCG) gyri together with the Subcentral Gyrus (SubCG) inferiorly and with the Paracentral Lobule (PaCLob) superiorly and already disposed along the medial surface of the brain hemisphere, constitute all together the so called Central Lobe (CLo) [17, 49–51], which then resembles an ellipse excavated by the Central Sulcus (CS) (Fig. 3).

Anteriorly to the Precentral Gyrus (PreCG) the Precentral Sulcus (PreCS) is almost always very evidently divided by the superficial connection of the Middle Frontal Gyrus (MFG) with the Precentral Gyrus (PreCG) in a superior and a inferior parts. While its superior part ends superiorly at an already medial connection of the

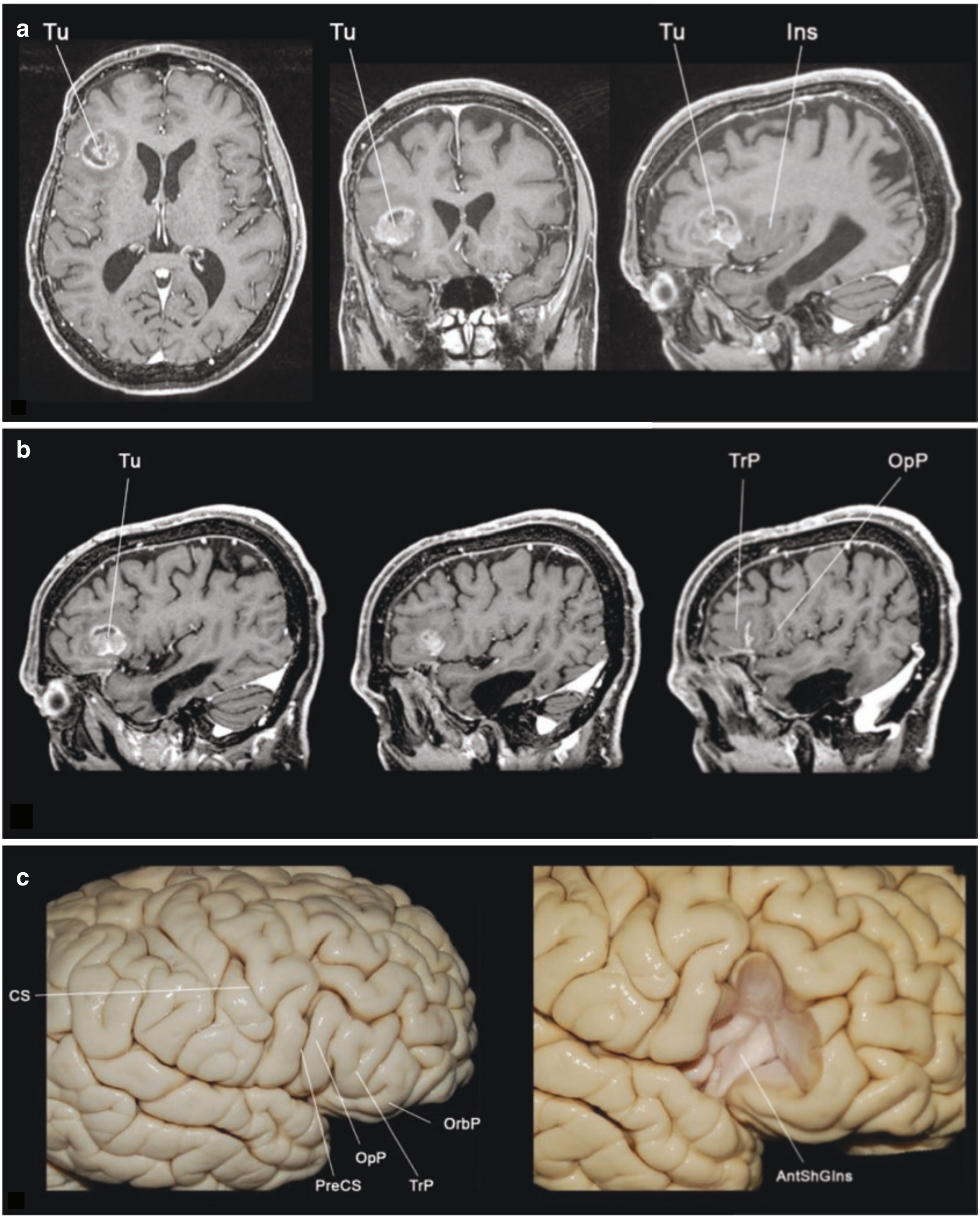

Fig. 8 (**a**) MRI images of a right fronto-opercular high grade glioma, which covers the most anterior aspect of the Insula, (**b**) inside-out images of the tumor showing it lies inside the Triangular Part of the Inferior Frontal Gyrus, (**c**) anatomical selective removal of the Triangular Part of the Inferior Frontal Gyrus exposing the Anterior Short Gyrus of the Insula, (**d**) Fronto-opercular Sulcal Key-points and surgical exposure of the Fronto-parietal Operculum, (**e**) microneurosurgicasl selective removal of the Triangular Part of the Triangular Part of the Inferior Frontal Gyrus, exposing and removing the underlying tumor, (**f**) Post-operative MRI images. *AntShGIns* Anterior Short Gyrus of the Insula, *ASyP* Anterior Sylvian Point, *CS* Central Sulcus, *IFS/PreCS* Inferior Frontal and Precentral Sulci Meeting Point, *Ins* Insula, *IRP* Inferior Rolandic Point, *OpP* Opercular Part of the Inferior Frontal Gyrus, *OrbP* Orbital Part of the Inferior Frontal Gyrus, *PreCS* Precentral Sulcus, *TrP* Triangular Part of the Inferior Frontal Gyrus, *Tu* Tumor

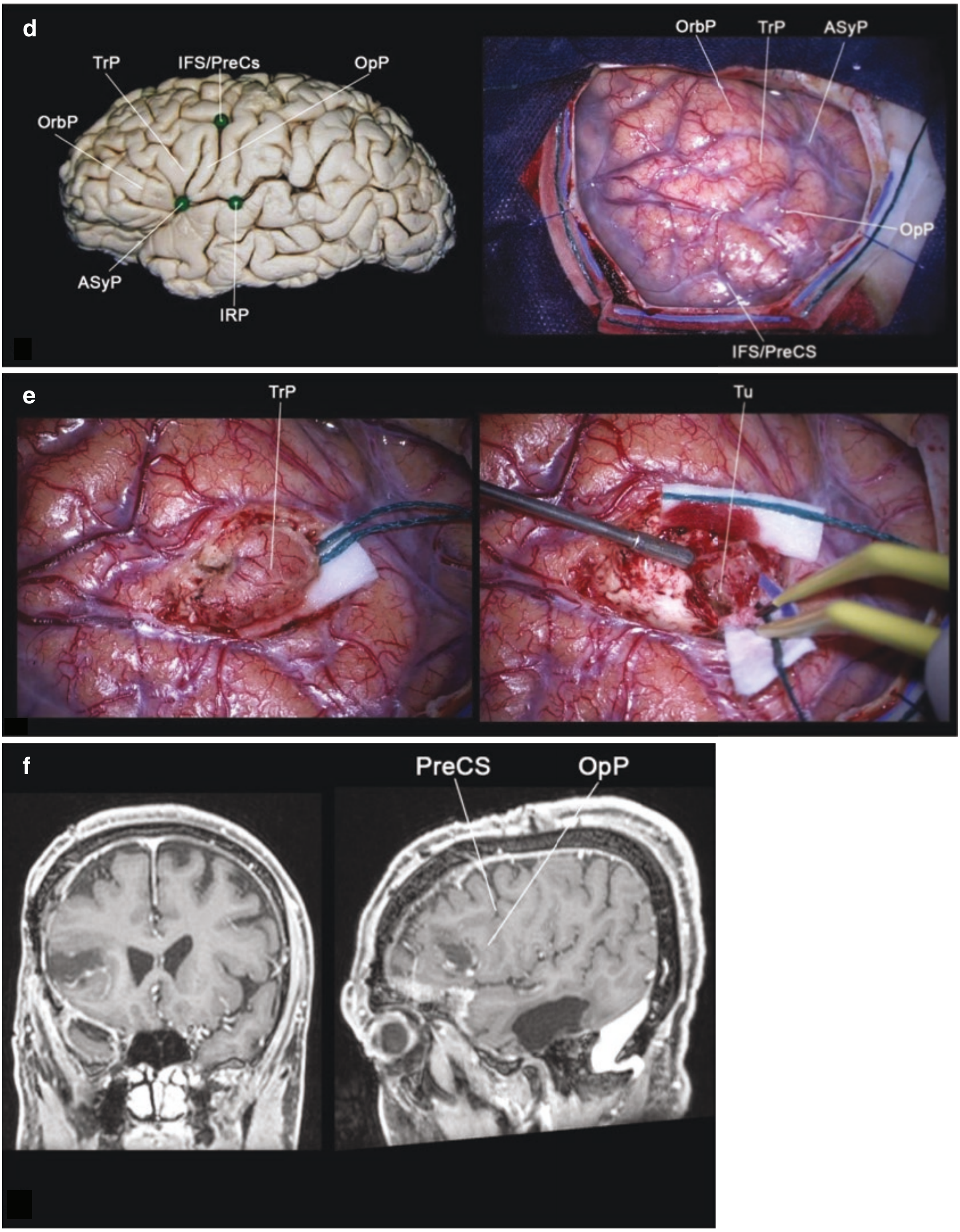

Fig. 8 (continued)

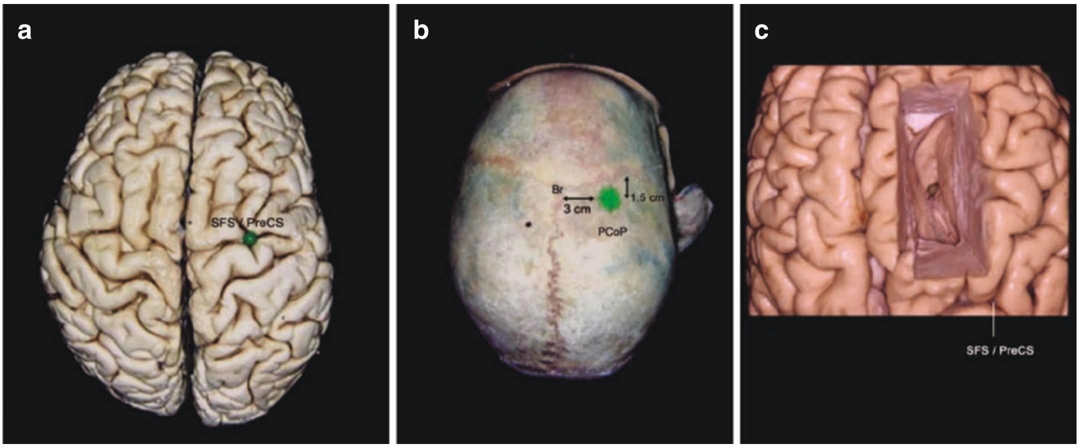

Fig. 9 (**a**) Superior Frontal and Precentral Sulci Meeting Point; (**b**) and its corresponding cranial site: the Superior Frontal and Precentral Sulci Meeting Point (SFS/PreCS) is located underneath the cranial site situated 1.5 cm posterior to the Coronal Suture and 3 cm lateral to the Sagittal Suture, and (**c**) relationship of the superior frontal sulcus with the anterior horn and body of the lateral ventricle. *Br* Bregma, *CS* Central Sulcus, *PreCS* Precentral Sulcus, *SFS/PreCS* Superior Frontal and Precentral Sulci Meeting Point

Superior Frontal Gyrus (SFG) with the Precentral Gyrus (PreCG), the inferior part of the Precentral Sulcus (PreCS) always ends inside the evident U-shaped Opercular Part (OpP) of the Inferior Frontal Gyrus (IFG) [24, 28, 52] (Fig. 2).

The Central Sulcus (CS) separates the primary motor and the somatosensory cortical areas respectively located along the Precentral Gyrus (PreCG) and the narrower Postcentral Gyrus (PostCG). It starts in or near the superomedial border of the hemisphere slightly behind the midpoint between the frontal and occipital poles [39], and runs resembling a lengthened italic S [53] downward and forwards almost always as a continuous sulcus [40], to end usually a little above the Sylvian Fissure (SyF) or, less frequently, inside it (Figa. 2 and 3).

The cranial-cerebral relationships of the Central Sulcus (CS) are shown in Fig. 11.

Posteriorly to the Postcentral Gyrus (PostCG) the Postcentral Sulcus (PostCS) is usually interrupted more frequently due to a connection between the Postcentral Gyrus (PostCG) and the Superior Parietal Lobule (SupPaLob) [40]. Its inferior part is superiorly very frequently continuous with the Intraparietal Sulcus (IPS) [24, 45], and inferiorly it always ends inside a U-shaped connection between the Postcentral Gyrus (PostCG) and the Supramarginal Gyrus (SMG) [24, 29] (Fig. 2).

Looking from above at the superior or opercular surface of the temporal lobe, which lies inside the Sylvian Fissure (SyF), the always evident Transverse Gyrus of Heschl (HeG) divides this surface in two planes. The Polar Plane (PoPl) anteriorly, which is oblique and which covers approximately the inferior half of the insular surface, and the Temporal Plane (TPl) posteriorly which is always flat and triangular with its apex next to the Atrium (Atr) (Fig. 3a).

Given these evident and constant obliquity and flatness of these two planes, a coronal MRI anterior to the Heschl's Gyrus (HeG) will show the Sylvian Fissure (SyF) always oblique while a coronal MRI posterior to it will always disclose the Sylvian Fissure (SyF) flat (Fig. 12c).

Another constant feature of the Heschl's Gyrus (HeG) is that along the Sylvian Fissure (SyF) it always presents as a bulge, a prominence, with the base of the Postcentral Gyrus (PostCG) always lying over this bulge (Fig. 12a, b).

The interesting and close cranial-cerebral relationships of the Squamous Suture (SqSut) and the Sylvian Fissure (SyF), the Heschl's Gyrus (HeG) and the Fronto-Opercular Key Points is shown in Fig. 13.

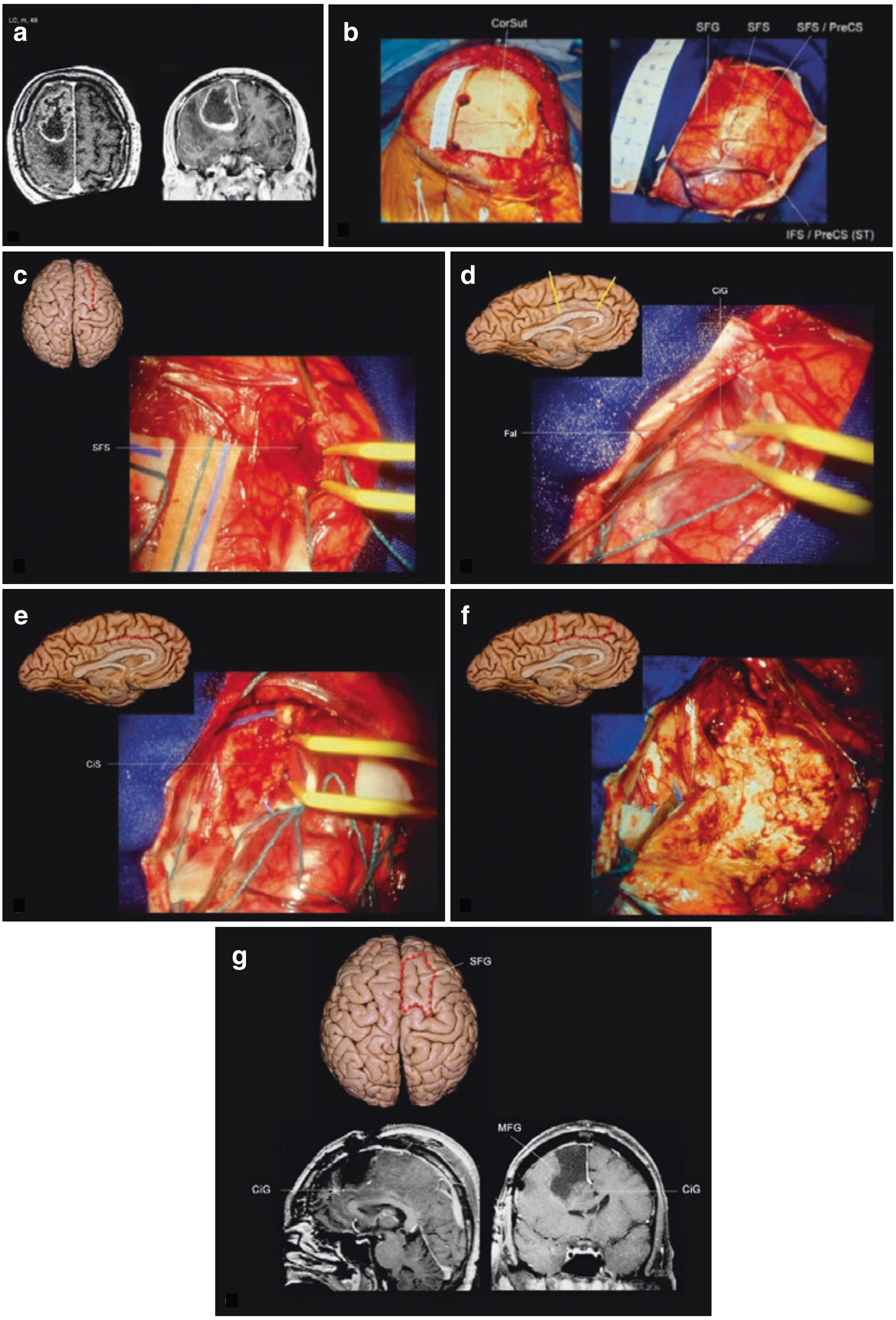

Fig. 10 Sulcal to sulcal resection of a high grade glioma of the right superior Frontal Gyrus. (**a**) MR images of the tumor occupying the Superior Frontal Gyrus; (**b**) craniotomy extending 2–3 cm posteriorly to the Coronal Suture in order to expose the Precentral Sulcus and the Superior Frontal/Precentral Sulci Meeting Point which should correspond to the posterior limit of the resection; operative view and identification of the main anatomical landmarks; (**c**) opening of the Superior Frontal Sulcus; (**d**) identification of the Cingulate Gyrus within the Interhemispheric Fissure; (**e**) opening of the Cingulate Sulcus; (**f**) cavity after en bloc removal of the posterior aspect of the Superior Frontal Gyrus containing the tumor; (**g**) post-operative MR images. *CiG* Cingulated Gyrus, *CiS* Cingulate Sulcus, *CoSut* Coronal Suture, *Fal* Falx, *IFS/PreCS(ST)* Inferior Frontal and Precentral Sulci Meeting Point underneath the Stephanion, *St* Stephanion (Meeting Point of the Coronal Suture and Superior Temporal Line), *MFG* Middle Frontal Gyrus, *SFG* Superior Frontal Gyrus, *SFS/PreCS* Superior Frontal and Precentral Sulci Meeting Point, *SFS* Superior Frontal Sulcus

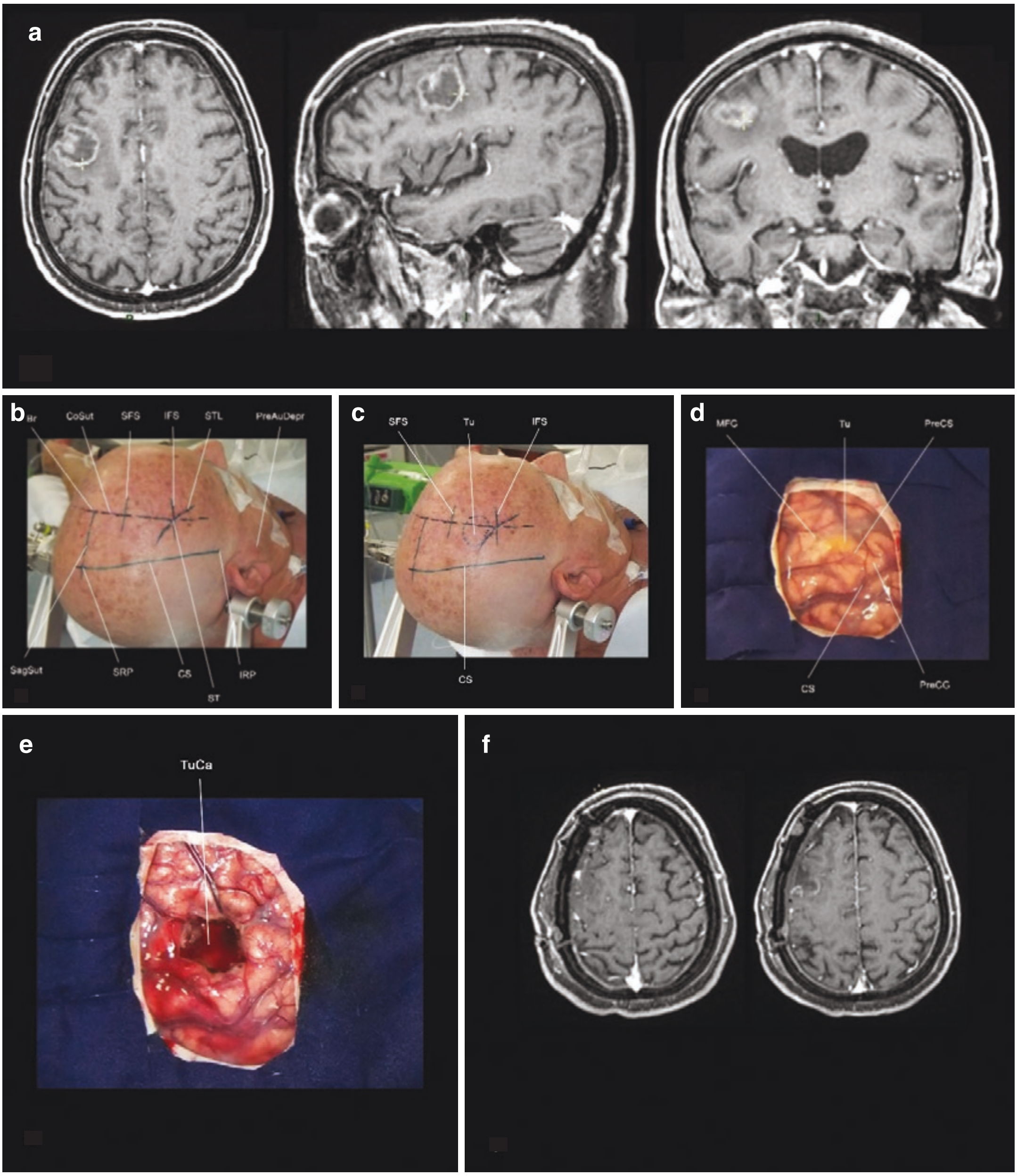

Fig. 11 Resection of a high grade glioma located in the right middle frontal gyrus just anteriorly to the precentral sulcus. (**a**) preoperative MR images; (**b**) main frontal anatomical landmarks and their related sulci: the central sulcus between the Superior Rolandic Point (located 5 cm posterior to the Bregma) and the Inferior Rolandic Point (4 cm superior to the preauricular depression), the Superior Frontal Sulcus which runs approximately 3 cm lateral to the Sagittal Suture, the most posterior aspect of the Inferior Frontal Sulcus underneath the Stephanion (meeting point of the coronal suture with the Superior Temporal Line; (**c**) location of the tumor in the posterior aspect of the right Middle Frontal Gyrus; (**d**) exposure of the brain surface and identification of the sulci and gyri; (**e**) tumor cavity after the resection; (**f**) post operative MR images. *Br* Bregma, *CoSut* Coronal Suture, *CS* Central Sulcus, *IFS* inferior Frontal Sulcus, *IRP* Inferior Rolandic Point, *MFG* Middle Frontal Gyrus, *PreAuDepr* Preauricular Depression, *PreCG* Precentral Gyrus, *PreCS* Precentral Sulcus ,*SagSut* Sagittal Suture, *SFS* Superior Frontal Sulcus, *SRP* Superior Rolandic Point, *St* Stephanion (meeting point of the Coronal Suture and Superior Temporal Line), *STL* superior temporal line, *Tu* tumor, *TuCa* tumor cavity

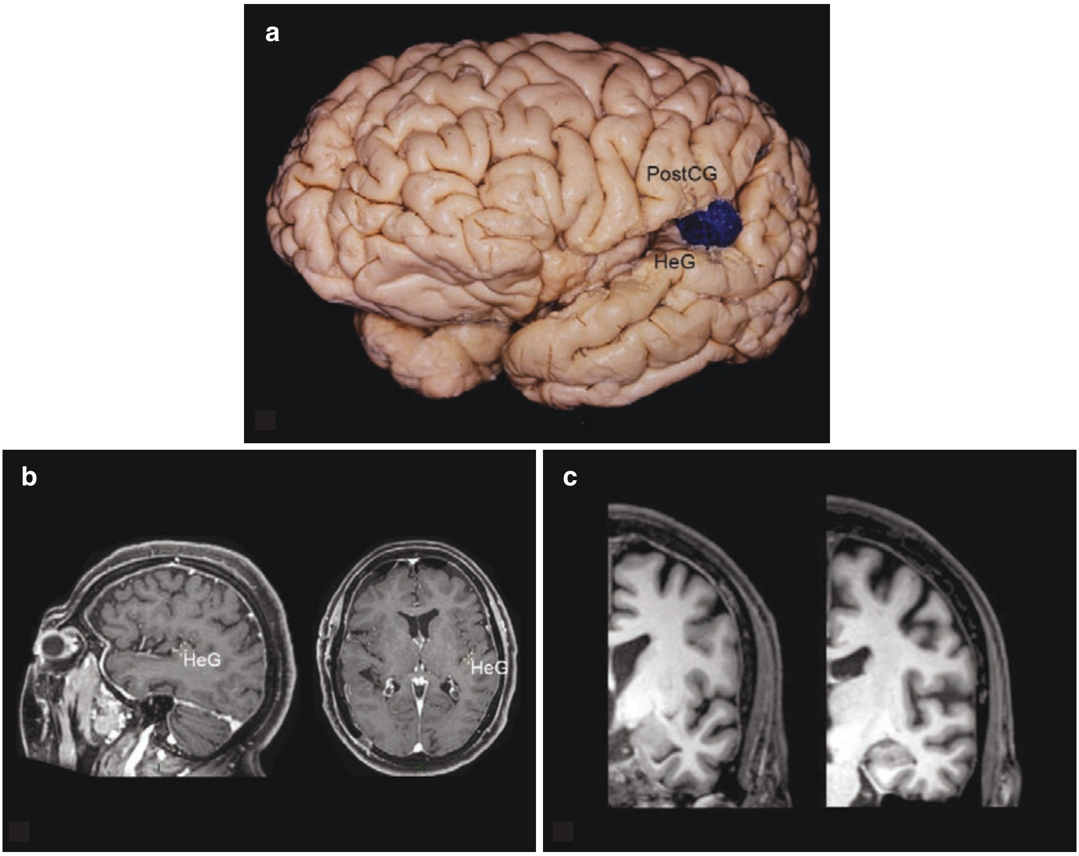

Fig. 12 (**a**, **b**) the Heschl's Gyrus (HeG) forms an evident prominence along the Sylvian Fissure (SyF), and the base of the Postcentral Gyrus (PostCG) always lies over the Heschl's Gyrus (HeG); (**c**) in MRI coronal cuts, the Sylvian Fissure (SyF) is oblique anteriorly to the Heschl's Gyrus (HeG) and is flat posteriorly to it

Operculi in Latin mean covers, curtains and in neuroanatomy correspond to the covers of the Insula (Ins). While the Frontoparietal Operculum (FPOp), which extends from the Horizontal Ramus (HR) to the Posterior Ascending Ramus (PostAsR) of the Sylvian Fissure (SyF) covers approximately the superior half of the Insula (Ins), the Temporal Operculum (TOp) which corresponds to the Superior Temporal Gyrus (STG) and its Polar and Temporal Planes (PoPl, TPl) divided by the Transverse Gyrus of Heschl (HeG), covers approximately the inferior half of the Insula (Ins) [24, 28] (Fig. 3b).

The Insula (Ins) is currently considered one of the cerebral lobes [54–56], and its surface corresponds to the outer surface of the Central Core (CCo) of the brain which is an anatomical very well defined block that harbors part of the Basal Ganglia (BaGa) and the Thalamus (Th) with the Internal Capsule (IntCaps) in between [32, 57]. The Apex (Ap) of the Insula (Ins) lies anteriorly and inferiorly within its surface, is located underneath the Anterior Sylvian Point (ASyP), and covers the Uncinate and its adjoining and posterior Inferior Fronto-Occipital Fascicle (UF, IFOF).

While the anterior half of the Insula (Ins) is related with the anterior half of the Putamen (Put), Anterior Limb of the Internal Capsule (AntLIntCaps), Head of the Caudate Nucleus (HeCa) and with the Frontal Horn of the Lateral Ventricle (FHoLatV), the posterior half of the Insula (Ins) is related with the posterior half of the Putamen (Put), Posterior Limb of the Internal Capsule (PostLIntCaps), Thalamus (Th) and with the IIIrd Ventricle cavity (IIIv) (Fig. 3b).

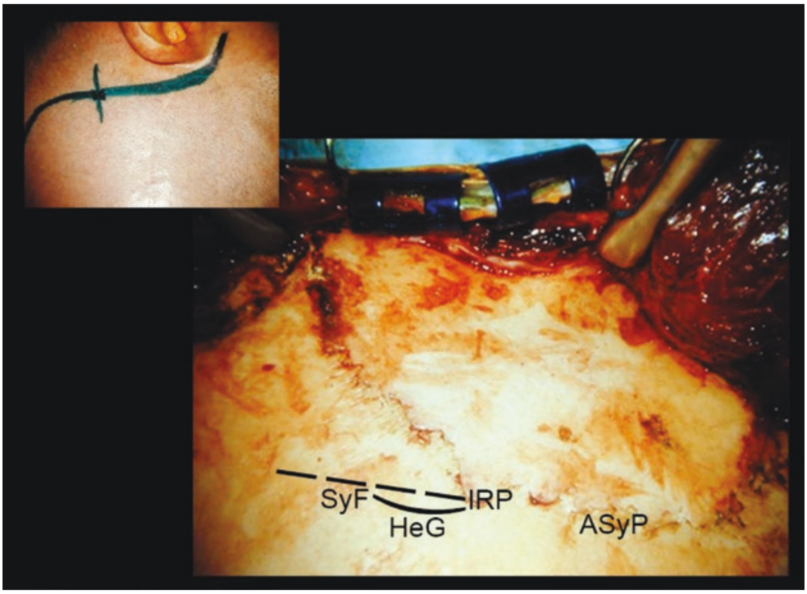

Fig. 13 The Squamous Suture and the Frontoparietal Operculum. While the anterior half of the Squamous Suture (SqSut) runs approximately over the anterior aspect of the Sylvian Fissure (SyF), its posterior half descends while the posterior aspect of the Sylvian Fissure (SyF) ascends. The highest point of the Squamous Suture (SqSut) which correlates with this turning point lies over the Inferior Rolandic Point (IRP) which corresponds to the projection of the Central Sulcus (CS) over the Sylvian Fissure (SyF). The Subcentral Gyrus (SubCG) lies then underneath the mid and upper segment of the Squamous Suture (SqSut). The Anterior Sylvian Point (ASyP) lies 2–2.5 cm [27] anteriorly to the Inferior Rolandic Point (IRP) and along the Sylvian Fissure (SyF), and immediately posterior to the Inferior Rolandic Point (IRP) lies the most lateral aspect of the Heschl's Gyrus (HeG) which in turn lies underneath the base of the Postcentral Gyrus (PostCG)

The body of the Lateral Ventricle (BoLatV) lies above the Thalamus (Th), the Atrium (Atr) lies posterior to the Thalamus (Th), and the Inferior Horn of the Lateral Ventricle (InfHoLatV) lies inferior to the Thalamus (Th), respectively then superior, posterior and inferior to the Central Core (CCo). The Heschl's Gyrus (HeG) runs obliquely and anteriorly to posteriorly towards the Atrium (Atr), hence posteriorly to the Internal Capsule (IntCaps) (Fig. 3b).

Inferiorly to the Sylvian Fissure (SyF) the Superior, Middle and Inferior Temporal Gyri (STG, MTG, ITG) are separated respectively by the Superior and Inferior Temporal Sulci (STS, ITS) (Fig. 2).

While the Superior Temporal Sulcus (STS), just as the Superior Frontal Sulcus (SFS), is usually almost continuous since it usually has at least one long continuous and deep segment, the Inferior Temporal Sulcus (ITS), just as the Inferior Frontal Sulcus (IFS), is always an interrupted sulcus formed by multiple segments. Contrary to the Superior and Middle Temporal Gyri (STG, MTG), the Inferior Temporal Gyrus (ITG) is very short along its lateral aspect, but it is broad along its base which lies over the middle fossa floor and the superior aspect of the Petrous Part of the Temporal bone. Given its low height and non-continuity, the Inferior Temporal Sulcus (ITS) usually is not easily identifiable (Fig. 2).

The parietal surface is divided by the evident Intraparietal Sulcus (IPS) in the quadrangular Superior Parietal Lobule (SPLob) which is continuous with the Precuneus Gyrus (PreCu) along the superomedial border of the cerebral hemisphere, and in the Inferior Parietal Lobule (IPLob) which is formed by the Supramarginal Gyrus (SMG) anteriorly and the Angular Gyrus (AG) posteriorly, separated by the Intermediary Sulcus of Jensen (ISJ) (Fig. 2).

The Intraparietal Sulcus (IPS) is either longitudinal and parallel to the superomedial border or

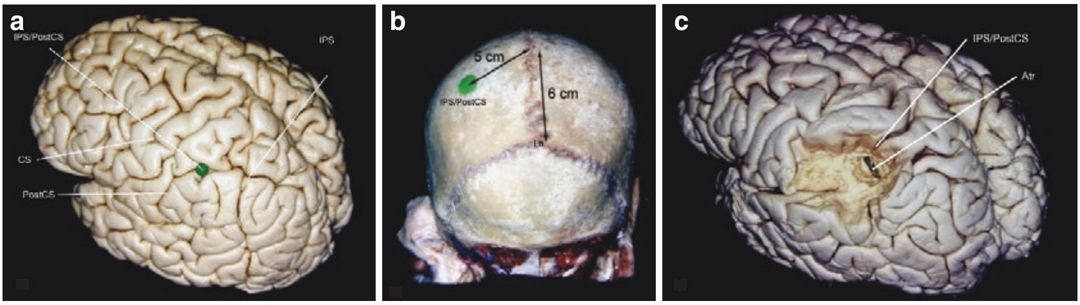

Fig. 14 (**a**) Intraparietal and Postcentral Sulci Meeting Point, or anterior projection of the Intraparietal Sulcus on the Postcentral Sulcus Point when there is an interruption between both sulci; (**b**) its corresponding cranial site; and (**c**) relationship of the Intraparietal and Postcentral sulci point with the Atrium of the Lateral Ventricle. *Atr* Atrium of Lateral Ventricle, *CS* Central Sulcus, *IPS/PostCS* Intraparietal and Postcentral Sulci Meeting Point, *IPS* Intraparietal Sulcus, *La* Lambda, *PostCs* Postcentral Sulcus

is oblique forming an arch with an inferior concavity. It is frequently interrupted and usually continuous with the inferior half of the Postcentral Sulcus (PostCS).

The Intraparietal and Postcentral Sulci Meeting Point (IPS/PostCS) is then an important Sulcal Key Point, and its cranial and deep cerebral (atrial) relationships are shown in Fig. 14.

The Intermediary Sulcus of Jensen (ISJ) always corresponds to a posterior and inferior branch of the Intraparietal Sulcus (IPS) (Fig. 2a). The IPS frequently also has an anterior and superior vertical branch which corresponds to the Transverse Parietal Sulcus of Brissaud (TrPSBr) that penetrates and divides the Superior Parietal Lobule (SupPaLob).

While the Supramarginal Gyrus (SMG) is very constant regarding its quadrangular shape surrounding the superior and distal end of the Sylvian Fissure (SyF), giving its name, the Angular Gyrus (AG) usually is ill-defined anatomically and does not have the classical horseshoe shape generally shown in textbooks (Fig. 2).

The anterior aspect of the Supramarginal Gyrus (SMG) lies underneath the most prominent point of the parietal tuberosity as shown in Fig. 15.

While the Sylvian Fissure (SyF) ends as a bifurcation at the so called Posterior Sylvian Point (PostSyP), giving rise to a very constant Posterior Ascending Ramus (PostAsR) that always penetrates inside the Supramarginal Gyrus (SMG), and a very variable, sometimes absent, descending branch, the Superior Temporal Sulcus (STS) which always ends posteriorly to the Posterior Sylvian Point (PostSyP), as a bifurcation or as a trifurcation, with its more horizontal distal end penetrating inside the Angular Gyrus (AG). Its more superior branch usually corresponds to the Intermediary Sulcus of Jensen (ISJ), and its more inferior branch is very variable (Fig. 2)

The Intermediary Sulcus of Jensen (ISJ) is then a branch of the Intraparietal Sulcus (IPS) and frequently corresponds also to a distal and superior branch of the Superior Temporal Sulcus (STS). When interrupted, its interruption is due to a connection between the Supramarginal (SMG) and Angular (AG) gyri (Fig. 2).

An actual surgical example of the Parietal Sulcal Key Points application is shown in Fig. 16.

Despite being less well defined and less anatomically constant than the gyri of other dorsal cortical areas, the occipital gyri of the superolateral cerebral surface tend to consist of two or three gyri which converge posteriorly to form the occipital pole of each hemisphere. While the Superior and Inferior Occipital Gyri (SOG, IOG) are anatomically more constant, the Middle Occipital Gyrus (MOG) is much more variable regarding its characterization (Fig. 2).

The Inferior Occipital Gyrus (IOG) is always placed horizontally along the inferolateral margin of the cerebral hemisphere, with its base lying over the tentorium. Anteriorly, it is mostly continuous with the Inferior Temporal Gyrus (ITG),

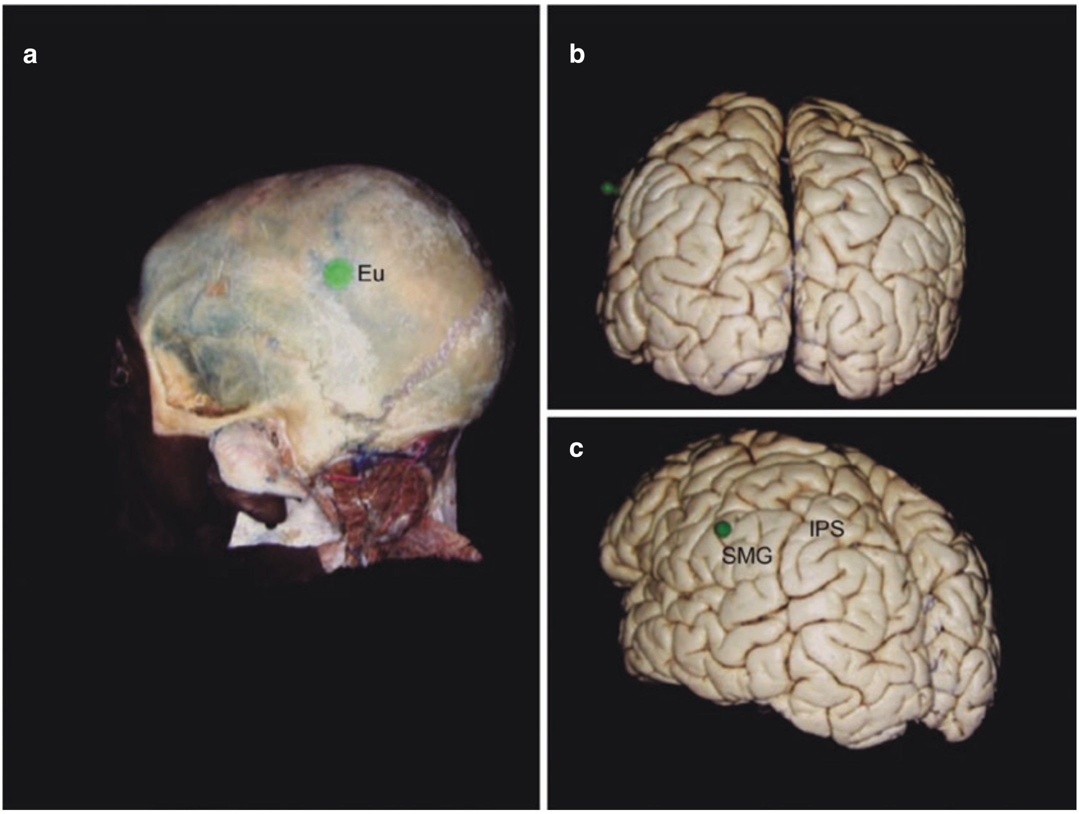

Fig. 15 The Euryon and the Supramarginal Gyrus. (**a**) the Euryon (Eu) corresponds to the most prominent point of the parietal tuberosity or bossa; (**b**, **c**) and lies over the superior aspect of the Supramarginal Gyrus (SMG). *AG* Angular Gyrus, *Eu* Euryon, *IPS* Intraparietal Sulcus, *SMG* Supramarginal Gyrus

and posteriorly it extends medially around the occipital pole becoming continuous with the Lingual Gyrus (LiG) within the medial surface of the hemisphere. Superiorly, the Inferior Occipital Gyrus (IOG) is delimited by the Inferior [11, 40] or Lateral [40, 45] Occipital Sulcus (IOS, LatOS) which frequently is anteriorly directly connected to the Inferior Temporal Sulcus (ITS) [40]. A shorter accessory lateral occipital sulcus frequently runs below the main one [48] (Figs. 2 and 3a).

The Superior Occipital Gyrus (SOG) corresponds usually to a well defined vertical gyrus placed along the Interhemispheric Fissure, which is continuous along the superomedial margin of the hemisphere with the Cuneus Gyrus (CuG) already within the cerebral medial surface. Superiorly, the Superior Occipital Gyrus (SOG) is delimited by the depth of the Parieto-Occipital Sulcus (POS) on the superolateral hemispheric surface which corresponds to the Parieto-Occipital Incisure (POInc), and is superiorly continuous with the Superior Parietal Lobule (SPLob) through the Parieto-Occipital Arcus (POAr) that encircles the Parieto-Occipital Incisure (POInc) and which corresponds to the First or Superior Parieto-Occipital "plis de passage" of Gratiolet (Fig. 3a).

The Intraparietal Sulcus (IPS) systematically extends longitudinally and inferiorly into the occipital lobe [40] becoming then the Intra-Occipital Sulcus (InOS) [11, 24, 45, 58], or Superior Occipital Sulcus (SOS) [11, 45], delimiting the Superior Occipital Gyrus (SOG) laterally. The intra-occipital sulcus can occasionally descend as far as the occipital pole [58] characterizing then a long and vertical sulcus, but most frequently it terminates as a T end which corre-

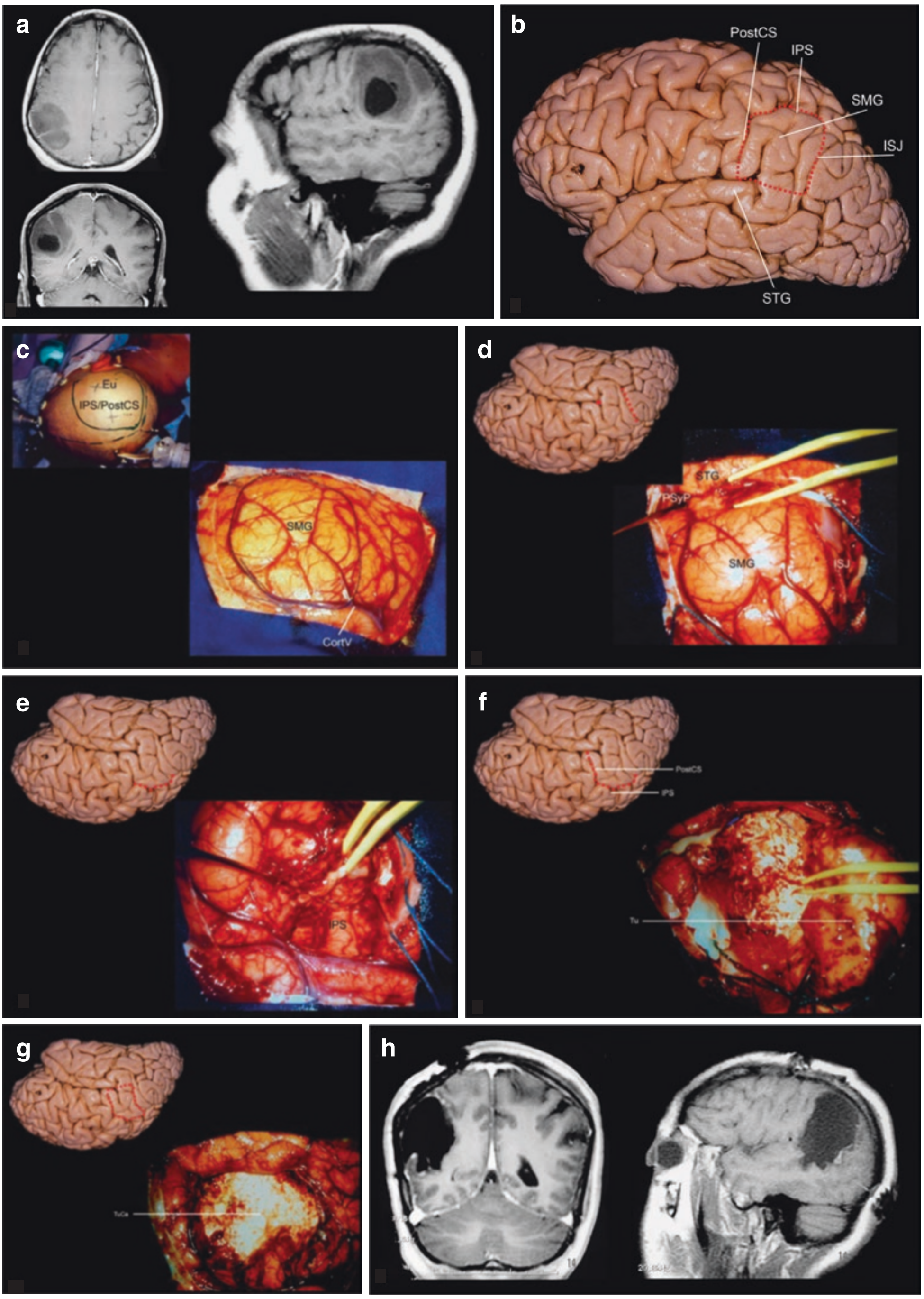

Fig. 16 Anatomical resection of the right Supramarginal Gyrus containing a low grade glioma. (**a**) preoperative MR images; (**b**) anatomical delineation of the Supramarginal Gyrus which is continuous with the Superior Temporal Gyrus along its base; (**c**) planning the craniotomy identifying the Euryon which lies above the Supramarginal Gyrus, a cortical vein running along the Intraparietal Sulcus, and exposure of the Supramarginal Gyrus which harbors the tumor; (**d**) opening of the Intermediary Sulcus of Jensen which separates the Supramarginal from the Angular Gyrus; (**e**) opening of the Intraparietal Sulcus; (**f**) opening of the Postcentral Sulcus which is continuous with the Intraparietal Sulcus, and en bloc removal of the tumor within the Supramarginal Gyrus; (**g**) tumor cavity; and (**h**) post operative MR images. *CortV* cortical vein, *Eu* Euryon, *IPS/PostCS* Intraparietal and Postcentral Sulci Meeting Point, *IPS* Intraparietal Sulcus, *ISJ* Intermediary Sulcus of Jensen, *PostCS* Postcentral Sulcus, *PSyP* Posterior Sylvian Point, *SMG* Supramarginal Gyrus, *STG* Superior Temporal Gyrus, *Tu* tumor, *TuCa* tumor cavity