Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Functional Transopercular Transinsular Mesialtemporal Surgical Corridor in Mesial Temporal-Insular Tumors

Víctor García-Milán
Marqués de Valdecilla University Hospital
Laura Ferrari
Consiglio Nazionale delle Ricerche, Istituto di Neuroscienze
Feras Fayez
King's College Hospital Foundation Trust
Mohammad Saleem Sioufi
King's College Hospital Foundation Trust
Louis Onyiriuka
King's College Hospital Foundation Trust
Yasir Chowdhury
King's College Hospital Foundation Trust
Antony Kaldas
King's College Hospital Foundation Trust
Ali Elhag
King's College Hospital Foundation Trust
Asfand Baig Mirza
Queens Hospital
Alba Diaz-Baamonde
King's College Hospital Foundation Trust
Ana Mirallave-Pescador
King's College Hospital Foundation Trust
Hilary Wren
King's College Hospital Foundation Trust
Marco Borri
King's College Hospital Foundation Trust
Joseph Jarosz
King's College Hospital Foundation Trust
Richard Gullan
King's College Hospital Foundation Trust
Keyoumars Ashkan

King’s College Hospital Foundation Trust

Ranjeev Bhangoo

King’s College Hospital Foundation Trust

Francesco Vergani

King’s College Hospital Foundation Trust

José Pedro Lavrador

Josepedro.lavrador@nhs.net

King’s College Hospital Foundation Trust

Case Report

Keywords: Insular Cortex, Temporal Lobe, Diffusion Tensor Imaging, Intraoperative Neurophysiological Monitoring.

Posted Date: September 25th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10766615/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Transcortical approaches to insula tumours have gained popularity in the recent years alongside with the widespread use of awake surgical techniques and intraoperative neuromonitoring developments. The transopercular transinsular mesialtemporal surgical corridor offers a functional approach for accessing mesial temporal-insular lesions.

Case presentations and Surgical technique:

A 36-year-old woman who presented with epileptic seizures and was found to have a left temporo-insular lesion on MRI. The technique performed through the temporal *opercula* after cortical mapping for the relevant cognitive functions – language, cognition and motor. Preoperative cortical mapping with navigated transcranial magnetic stimulation and/or functional MRI provide significant preoperative information to inform intraoperative cortical mapping. After skeletonizing the M3 branches, the approach follows a surgical structural corridor between arcuate fasciculus, superior longitudinal fasciculus system, fronto-aslant tract, and corticospinal tract superiorly and medially, inferior fronto-occipital fasciculus medially, uncinate fasciculus anteriorly, inferior and medial longitudinal fasciculus laterally and optic radiations posteriorly, reaching the mesial temporal region – uncus and hippocampal formation. At subcortical level, the boundaries of this structural corridor are functionally identified with the appropriate intraoperative testing. Asleep intraoperative testing focuses on motor evoked potentials (MEPs) mapping and monitoring using either high frequency (HFS) or low frequency (LFS) techniques, somatosensory evoked potentials (SSEPs) and/or cortico-cortical evoked potentials (CCEP). Awake intraoperative mapping and monitoring relies on the above mentioned techniques and temporary cognitive function disruption using language, social and motor cognition tasks - with either HFS or LFS techniques.

Conclusion

The functional transopercular transinsular mesialtemporal surgical corridor enables maximal safe resection of tumors extending to the uncus and hippocampal formation while preserving functional cortical-subcortical structures and minimizing vascular morbidity.

Background

The functional transopercular transinsular mesialtemporal surgical corridor to mesial temporal-insular tumours enables access to the uncus and hippocampal formation through a cortical-subcortical corridor that respects critical cortical areas and white matter tracts. This surgical corridor is entered via the temporal *opercula* based on functional boundaries and primarily targets insular Zones I and IV as

classified by Berger-Sanai [1]. The subcortical corridor crosses the plane of ipsilateral M3 branches between the uncinate fasciculus (UF) anteriorly; the arcuate fasciculus (AF), superior longitudinal fasciculus System (SLF), fronto-aslant tract (FAT) and corticospinal tract (CST) superiorly and medially; inferior fronto-occipital fasciculus (IFOF) medially; the medial and inferior longitudinal fasciculus (MLF and ILF) laterally; and optic radiations (OR) posteriorly, enabling safe access to the mesial temporal structures and resection of tumours involving the insula (from cortex to *capsula externa*) and hippocampal formation. The intraoperative functional identification of this corridor uses asleep and awake mapping and monitoring techniques focused on motor evoked potentials (MEPs), somatosensory evoked potentials (SSEPs) (asleep techniques) and temporary cognitive function disruption (awake technique) using either high-frequency stimulation (HFS) or low-frequency stimulation (LFS).

Relevant Anatomy:

The temporal *operculum* corresponds to the superior temporal *gyrus* **(**Fig. 1a**)**. Surgical removal of this cortical area exposes the *limen insulae* inferiorly, the anterior short *gyri* anteriorly, and the *inferior limiting sulcus* inferiorly and posteriorly [2, 3] **(**Fig. 1b**)**. The resection of the anterior insular cortex subsequently reveals the extreme capsule, a thin layer of white matter composed predominantly of short subcortical association fibers known as U-fibers. These fibers are responsible for local connectivity, linking adjacent cortical regions, specifically connecting the insular cortex with the immediately surrounding opercular regions and facilitating integration between neighbouring cortical functions [4]. Exposure of the extreme capsule represents the anatomical transition into the deeper subcortical white matter layers of the central core [5].

Deep to the extreme capsule lies the *claustrum*, followed medially by the external capsule, which contains two major long association fiber tracts: UF and IFOF. The UF follows a hook-shaped course connecting the anterior temporal lobe to the orbitofrontal cortex, while the IFOF extends from the occipital and posterior temporal lobes toward the frontal lobe [6]. These tracts converge beneath the anteroinferior apex of the insula, in proximity to the limen insulae, and from there proceed medially through the cerebral isthmus—a compact white matter funnel that connects the central core with the medial temporal structures and subcortical projection systems [5].

Subcortical dissection navigates between major fibers tracts (UF anteriorly; AF, FAT, CST and SLF superiorly and medially; IFOF medially; MLF and ILF laterally; OR posteriorly) **(**Fig. 2**)**.

At the medial and inferior extent of this surgical corridor lies the uncus and the hippocampal head, which are frequently involved in large insulo-temporal tumors. Just beneath these structures, the oculomotor nerve emerges from the interpeduncular fossa and courses anterolaterally through the crural cistern, medial and inferior to the uncus. Its identification marks the inferior boundary of the dissection and confirms the medial extent of resection [7].

Laterally, the surgical corridor is defined by MLF and ILF, which extend longitudinally along the temporal lobe, providing clear lateral boundaries to the approach. Medially, access to the temporal horn of the

lateral ventricle is obtained through its roof, following the trajectory defined by the insular dissection and subcortical white matter navigation. Posteriorly, the surgical corridor is limited by the OR, which traverse transversely from medial to lateral—originating at the lateral geniculate body—before turning posteriorly around the ventricular roof. The transverse orientation of these sensory radiations contrasts with the longitudinal trajectory of association fiber tracts such as the IFOF, UF, MLF, ILF, and AF.

The M3 segment of the middle cerebral artery (MCA) corresponds to its opercular portion, where the artery and its branches curve around the opercular lips to exit the sylvian fissure and reach the cortical surface. During its trajectory, it gives rise to multiple cortical branches that radiate across the insular gyri, supplying the frontoparietal and temporal cortices. Among these are the long insular arteries, which traverse the insular cortex from superior to inferior, providing vascularization to both the insular and adjacent opercular regions. The radial and inferior orientation of these arteries serves as a crucial anatomical guide during microsurgical dissection of the Sylvian fissure and insular region. Understanding the distribution and directionality of these vessels is essential for preserving vascular integrity during surgical approaches involving the insula [8].

Case presentation:

In this work, we describe the case of a 36-year-old woman who presented with epileptic seizures and was found to have a left temporo-insular lesion on MRI. The lesion appeared hyperintense on FLAIR sequences, without contrast enhancement or diffusion restriction, consistent with a low-grade glioma. It involved the mesial temporal-insular structures with minor infiltration of the frontal *operculum* medial to the perforator arteries originating in the anterior perforator substance and slight posterior extension toward the occipital region via the *stratum sagittale*. Given its anatomical distribution and radiological characteristics, the patient was selected for resection using an asleep-awake transopercular transinsular mesialtemporal approach for function-guided tumour resection.

Surgical Technique

Preoperative planning and mapping

Preoperative imaging included high-resolution MRI with diffusion-weighted imaging sequences for tractography **(**Fig. 3**)** and (11)C-methionine positron emission tomography (MET-PET) for oncological metabolic assessment. MET-PET allows the detection of areas of increased amino acid uptake, providing higher sensitivity for tumor delineation compared to conventional MRI, and identifying metabolically active regions even in non-enhancing gliomas [9]. Navigated transcranial magnetic stimulation (nTMS) and functional MRI (fMRI) was performed to localize cortical areas related to language and motor function: Repetitive nTMS (rnTMS) - object and action naming present and past tense and upper and lower limbs motor function; fMRI - picture naming, verb generation and verb fluency **(**Fig. 4**)**. All anatomical and functional data were integrated into the neuronavigation system (eXimia – Nexstim, Helsinki, Finland), allowing for delineation of a safe cortical entry point through the anterior

opercular region and to plan a transinsular trajectory that respected the course of key subcortical and vascular structures.

Patient positioning

The patient was positioned in the supine position with the head fixed in a Mayfield head clamp. The head was rotated approximately 60 degrees to the right, allowing a direct line of sight to the anterior opercular region.

Craniotomy and cortical entry

A left fronto-temporal craniotomy was performed, centered over the pterional region to allow exposure of both the frontal and temporal opercula. After dural opening, initial cortical mapping under general anesthesia was conducted using HFS (train-of-5, 250 Hz, 500ms pulse duration) delivered via monopolar probe to identify motor areas, ensuring preservation of primary motor functions **(**Fig. 5a**)**. Subsequently, the patient was gradually awakened for detailed functional mapping. Awake cortical mapping utilized LFS (biphasic, 50–60 Hz) delivered via bipolar probe while the patient performed a comprehensive battery of language and cognitive tasks, including object naming, action naming in present and past tense, sentence repetition, sentence completion, and cognitive paradigms such as odd-one-out, motor cognition, and mentalizing tasks [10]. Once non-eloquent entry points were definitively identified and confirmed by real-time clinical responses, transcortical windows were created through the anterior temporal *operculum*. Special attention was given to the posterior limit of the cortical dissection. In surgeries involving the non-dominant hemisphere, the motor-related structures – primary motor cortex and CST - defined the critical posterior boundary in the absence of significant cognitive cortical domains. In dominant hemisphere procedures, posterior exploration was typically constrained anteriorly by language-related eloquent networks, including the ventral premotor cortex and associated FAT-AF complex.

Subcortical dissection and insular traversal

From the selected cortical entry points, subcortical dissection proceeded under continuous neuronavigational guidance and microscopic visualization **(**Fig. 5b**)**. The trajectory was oriented medially toward the limen insulae, carefully developing the corridor between the M3 branches of the MCA. Subpial dissection was used to avoid unnecessary cortical and vascular injury. Intraoperative dynamic subcortical mapping was performed involving a combined methodology of mapping and monitoring according to the subcortical structures of interest [11].

Intraoperative subcortical mapping involved a combined methodology, initiating with HFS (250 Hz) for dynamic subcortical screening, followed by confirmatory testing with low-frequency bipolar stimulation (60 Hz). Specific functional tasks were administered based on the tract under assessment **(**Fig. 6**)**.

- IFOF, UF, ILF, and MLF: semantic language tasks in the dominant hemisphere, mentalizing tasks in the non-dominant hemisphere.
- FAT: sentence completion tasks.
- AF: action naming and sentence repetition in the dominant hemisphere; mentalizing tasks in the non-dominant hemisphere.
- OR: visual evoked potential (VEP) stability assessment (asleep phase) and visual field mapping during awake surgery.

Stimulation responses confirmed corridor boundaries based on preoperative tractography. Positive responses were obtained predominantly over the IFOF, eliciting semantic language disturbances at stimulation thresholds ranging between 3–5 mA using high-frequency stimulation. These findings allowed real-time confirmation of the functional boundaries during corridor development **(**Fig. 5b, **numbers 1, 2 and 3)**.

Mesial temporal exposure

Progressive dissection through the cerebral isthmus allowed direct access to the uncus and the head of the hippocampus. These structures were visualized in continuity with the tumor and resected under microscopic guidance. The anatomical limit of the corridor was confirmed by identifying the oculomotor nerve, which was visualized in the depth of the crural cistern, medial and inferior to the resection plane. Resection was completed with preservation of the nerve and adjacent vascular structures. Hemostasis was carefully secured, and no subpial or vascular breach was observed during mesial dissection.

Final intraoperative assessment

After meticulous hemostasis, the dura mater was closed in a watertight fashion using interrupted sutures. Finally, the bone flap was repositioned and fixed with low-profile titanium plates, followed by careful anatomical closure of the scalp layers. The surgical technique is demonstrated in Additional file 1 (Video 1).

A postoperative MRI was obtained within the first 48 hours after surgery to assess the extent of resection and evaluate the preservation of surrounding anatomical structures **(**Fig. 7**)**.

Discussion

The evolution of insular glioma surgery reflects a progressive shift from initial skepticism and avoidance toward a functional, anatomy-based approach that enables maximal safe resection. In the 1980s, M. Gazi Yaşargil was among the first to demonstrate the technical feasibility of insular tumor removal using meticulous microsurgical dissection, emphasizing the importance of vascular preservation within the sylvian fissure. Building on this anatomical foundation, Uğur Türe further refined the understanding of insular sulcal and vascular anatomy through detailed cadaveric studies, facilitating more precise

planning of surgical corridors. In the early 2000s, Hugues Duffau revolutionized the field by integrating awake mapping and functional monitoring into glioma surgery. His work demonstrated that eloquent areas could be identified intraoperatively, allowing for more extensive resection of insular gliomas with acceptable functional outcomes. Duffau's contributions also reframed gliomas as network-based diseases, advocating for a connectomic approach that preserves white matter pathways. Mitchel Berger and colleagues contributed both technical innovation and a systematic framework for surgical decision-making. Their development of the Berger-Sanai classification provided a practical anatomical system to guide the selection of surgical approaches based on tumor location within the insula. Furthermore, Berger has emphasized the importance of combining anatomical knowledge with functional strategies, including tractography, neurophysiological monitoring, and multimodal imaging. Together, these contributions laid the foundation for modern insular glioma surgery, transforming it into a field where careful anatomical navigation and real-time functional assessment enable tailored, patient-specific resections [12].

This approach is indicated for large temporal-insular tumours with extension to the mesial temporal structures, particularly the uncus and hippocampal head, centred to Berger-Sanai Zones I and IV [1]. It is especially useful when a direct transsylvian route does not provide sufficient access or when a functional corridor can be safely planned between critical white matter tracts avoiding critical functional cortical structures. The approach is also advantageous in cases where preoperative tractography and intraoperative mapping allow for precise definition of subcortical anatomy, enabling maximal resection with functional preservation.

The transopercular transinsular mesialtemporal corridor offers a safe and functionally guided route to the anterior insula and mesial temporal structures; however, it presents important limitations. Its reach toward the superior insula is restricted, particularly for tumors located in Berger-Sanai Zones I and II [1]. In such cases, additional surgical corridors may be required to access these regions adequately and safely [13]. This approach requires a thorough understanding of the anatomical and functional organization of the insular and mesial temporal regions. Its application is limited by the availability and quality of preoperative tractography and intraoperative functional mapping, which are essential to define a safe surgical corridor. Patient cooperation during awake procedures is also critical, as the integrity of subcortical tracts is continuously monitored through active task performance [13, 14]. Inadequate patient collaboration or suboptimal mapping conditions may compromise the safety and extent of resection.

In lesions located in Berger-Sanai Zones III and IV with extensive temporal neocortical involvement, a classic anterior temporal lobectomy or selective amygdalohippocampectomy may be necessary to achieve maximal oncological benefit [15], particularly after the functional disconnection has been completed through the transinsular route. This underscores the importance of flexibility and adaptability in surgical planning.

As a transopercular approach, vasospasm remains a potential postoperative complication due to manipulation of M3 branches over the insular surface [16]. Additionally, if the ventricle is entered through its roof, blood may enter the ventricular system, increasing the risk of hydrocephalus or delayed complications [17].

Another consideration relates to the subcortical tracts at the boundaries of the corridor. Some of these, such as the MLF, are not consistently recognized or preserved in standard glioma surgery, despite their potential functional relevance in semantic processing and temporo-parietal integration [18]. The OR also represent a critical structure, particularly in surgeries involving the dominant hemisphere. While partial visual field deficits may be considered acceptable in glioma surgery to increase the extent of resection, their functional impact—especially in younger or highly active patients—must not be underestimated. Several studies have emphasized the clinical significance of preserving optic radiations when feasible, given the long-term quality-of-life implications of permanent visual deficits [19, 20].

Additionally, variability between asleep and awake mapping techniques can influence surgical strategy and outcomes [21]. Tumors involving extensive temporal neocortical areas require a broader surgical strategy; thus, this corridor cannot be used exclusively but should rather be integrated into a more comprehensive surgical approach. This corridor is particularly suitable for insular tumors extending to the hippocampal formation within the temporal lobe, preserving temporal neocortical structures and primarily involving paleo and archicortex regions [15].

To minimize complications, surgeons must rigorously follow preoperative imaging and functional mapping protocols. Comprehensive tractography should clearly delineate the medial, lateral, and posterior subcortical boundaries. Preoperative cortical mapping using nTMS and fMRI is essential for localizing language and motor areas. Intraoperative neurophysiological monitoring (IONM) further guides safe resection. Careful patient selection and detailed planning of stimulation paradigms are critical. During surgery, continuous neuronavigational guidance and frequent subcortical mapping checkpoints should be employed. Thorough patient preparation, including rehearsal of awake testing paradigms, significantly improves intraoperative cooperation and enhances the reliability of functional monitoring.

Patients should be clearly informed about the awake nature of the procedure and the importance of their cooperation during intraoperative testing. Potential risks, including language disturbances, cognitive impairments, seizures, transient or permanent neurological deficits, and vascular complications, should be thoroughly discussed. The benefits of maximal safe resection with detailed preoperative planning and advanced intraoperative monitoring techniques, aiming to preserve essential neurological functions, must be highlighted. Emphasis should be placed on realistic postoperative expectations and recovery timelines.

Conclusion

The functional Transopercular Transinsular Mesotemporal Surgical Corridor provides access to the hippocampal formation via an anterior fronto-temporal opercular corridor in temporo-insular tumours. Preoperative planning using tractography is critical to define a safe subcortical corridor and avoid injury to deep white matter tracts. Functional preoperative (nTMS and fMRI) and intraoperative (high frequency and low frequency stimulation) mapping ensures safe cortical and subcortical navigation. Cortical entry is performed through the anterior frontal and temporal opercula, avoiding eloquent cortex – motor, language and cognition. This approach enables maximal tumor resection with subcortical tract preservation and minimizing vascular morbidity in selected cases.

Abbreviations

Abbreviation
Full term
AF
Arcuate fasciculus
CCEP
Cortico-cortical evoked potential
CST
Corticospinal tract
FAT
Fronto-aslant tract
FLAIR
Fluid-attenuated inversion recovery
fMRI
Functional magnetic resonance imaging
HFS
High-frequency stimulation
IFOF
Inferior fronto-occipital fasciculus
ILF
Inferior longitudinal fasciculus
IONM
Intraoperative neurophysiological monitoring
LFS
Low-frequency stimulation
MCA
Middle cerebral artery
MEP
Motor evoked potential
MET-PET

[11C]-methionine positron emission tomography
MLF
Medial longitudinal fasciculus
MRI
Magnetic resonance imaging
nTMS
Navigated transcranial magnetic stimulation
OR
Optic radiations
rnTMS
Repetitive navigated transcranial magnetic stimulation
RMT
Resting motor threshold
SLF
Superior longitudinal fasciculus
SSEP
Somatosensory evoked potential
UF
Uncinate fasciculus
VEP
Visual evoked potential

Declarations

Ethics approval and consent to participate

Ethics approval was waived by the institution for this single case report.

Consent for publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images and video.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

There is no conflict of interest concerning the materials or methods used in this study or the findings specified in this research article.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-

profit sectors.

Authors' contributions

All authors contributed to the writing and editing of the manuscript. All authors read and approved the final manuscript.

References

1. Sanai N, Polley MY, Berger MS. Insular glioma resection: assessment of patient morbidity, survival, and tumor progression. J Neurosurg. 2010;112(1):1–9.
2. Rhoton AL Jr. The cerebrum. Anatomy. Neurosurgery. 2007;61(1 Suppl):37–118; discussion 118-9.
3. Türe U, Yaşargil DCH, Al-Mefty O, Yaşargil MG. Topographic anatomy of the insular region. J Neurosurg. 1999;90(4):720–733.
4. Demirtaş OK, Güngör A, Çeltikçi P, Çeltikçi E, Munoz-Gualan AP, Doğulu FH, et al. Microsurgical anatomy and insular connectivity of the cerebral opercula. J Neurosurg. 2022;137(5):1509–1523.
5. Ribas EC, Yagmurlu K, de Oliveira E, Ribas GC, Rhoton A Jr. Microsurgical anatomy of the central core of the brain. J Neurosurg. 2018;129(3):752–769.
6. Dziedzic TA, Bala A, Marchel A. Anatomical aspects of the insula, opercula and peri-insular white matter for a transcortical approach to insular glioma resection. Neurosurg Rev. 2022;45(1):793–806.
7. Xu Y, Mohyeldin A, Nunez MA, Doniz-Gonzalez A, Vigo V, Cohen-Gadol AA, et al. Microvascular anatomy of the medial temporal region. J Neurosurg. 2022;137(3):747–759.
8. Türe U, Yaşargil MG, Al-Mefty O, Yaşargil DCH. Arteries of the insula. J Neurosurg. 2000;92(4):676–687.
9. Kracht LW, Miletic H, Busch S, Jacobs AH, Voges J, Hoevels M, et al. Delineation of brain tumor extent with [11C]L-methionine positron emission tomography: local comparison with stereotactic histopathology. Clin Cancer Res. 2004;10(21):7163–7170.
10. Rossi M, Sciortino T, Conti Nibali M, Gay L, Viganò L, Puglisi G, et al. Clinical pearls and methods for intraoperative motor mapping. Neurosurgery. 2021;88(3):457–467.
11. Raabe A, Beck J, Schucht P, Seidel K. Continuous dynamic mapping of the corticospinal tract during surgery of motor eloquent brain tumors: evaluation of a new method. J Neurosurg. 2014;120(5):1015–1024.
12. Hervey-Jumper SL, Berger MS. Insular glioma surgery: an evolution of thought and practice. J Neurosurg. 2019;130(1):9–16.
13. Przybylowski CJ, Hervey-Jumper SL, Sanai N. Surgical strategy for insular glioma. J Neurooncol. 2021;151(3):491–497.
14. Lang FF, Olansen NE, DeMonte F, Gokaslan ZL, Holland EC, Kalhorn C, et al. Surgical resection of intrinsic insular tumors: complication avoidance. J Neurosurg. 2001;95(4):638–650.

15. Alkassm E, Grote A, Berger B, Woermann FG, Ersoy TF, Coras R, et al. Anatomy-guided resections for paralimbic tumors in the temporo-insular region: combining tumor and epilepsy surgery concepts. Front Neurol. 2024;15:1450027.
16. Przybylowski CJ, Baranoski JF, So VM, Wilson J, Sanai N. Surgical morbidity of transsylvian versus transcortical approaches to insular gliomas. J Neurosurg. 2020;132(6):1731–1738.
17. John JK, Robin AM, Pabaney AH, Rammo RA, Schultz LR, Sadry NS, et al. Complications of ventricular entry during craniotomy for brain tumor resection. J Neurosurg. 2017;127(2):426–432.
18. Sierpowska J, Gabarrós A, Fernández-Coello A, Camins À, Castañer S, Juncadella M, et al. White-matter pathways and semantic processing: intrasurgical and lesion-symptom mapping evidence. Neuroimage Clin. 2019;22:101704.
19. Gras-Combe G, Moritz-Gasser S, Herbet G, Duffau H. Intraoperative subcortical electrical mapping of optic radiations in awake surgery for glioma involving visual pathways. J Neurosurg. 2012;117(3):466–473.
20. Shi J, Lu D, Pan R, Chen H, Teng H, Xu Y, et al. Applications of diffusion tensor imaging integrated with neuronavigation to prevent visual damage during tumor resection in the optic radiation area. Front Oncol. 2022;12:955418.
21. Fernández Coello A, Moritz-Gasser S, Martino J, Martinoni M, Matsuda R, Duffau H. Selection of intraoperative tasks for awake mapping based on relationships between tumor location and functional networks. J Neurosurg. 2013;119(6):1380–1394.

Figures

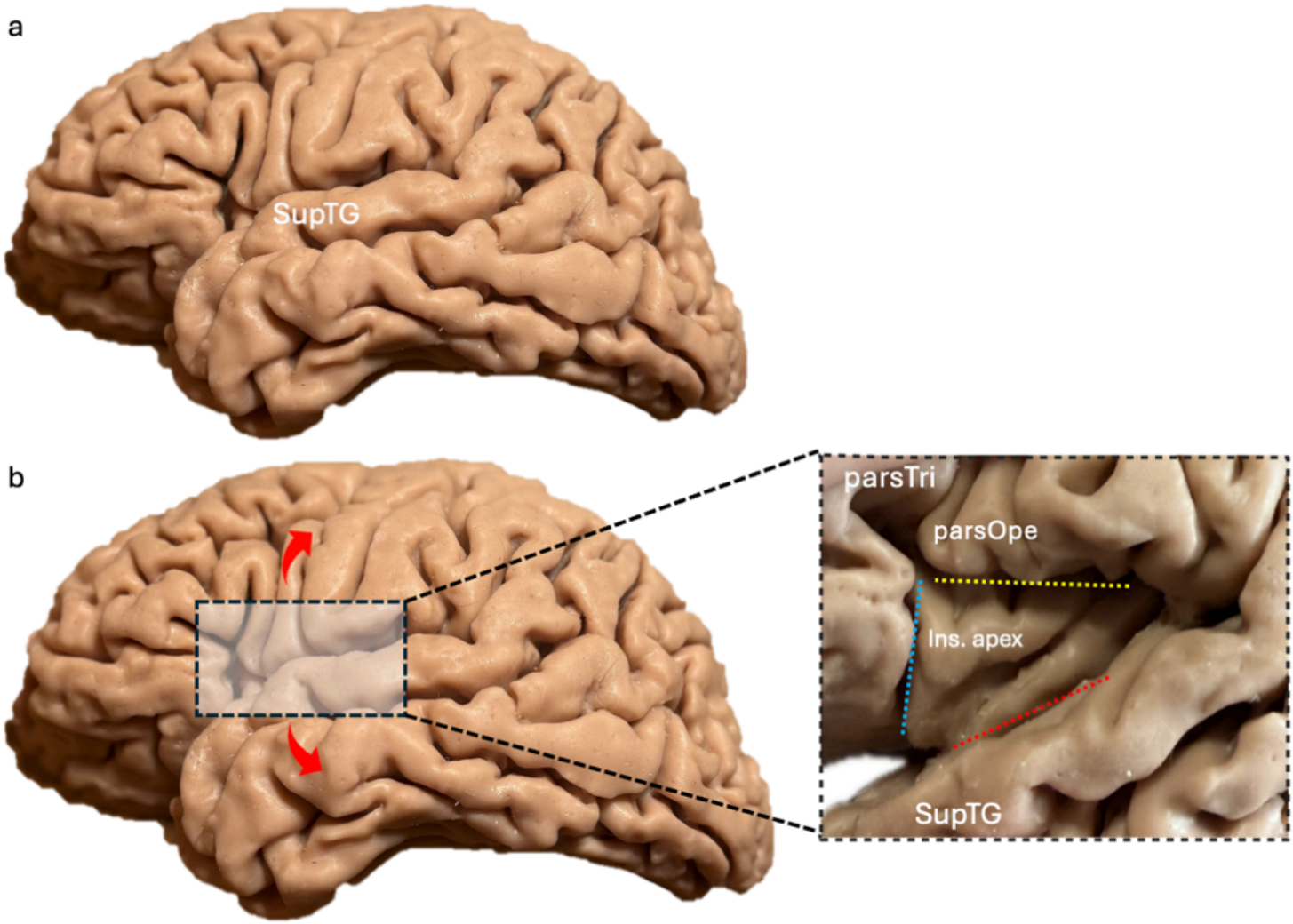


Figure 1

Cortical anatomy relevant to planning the transopercular transinsular mesotemporal approach. (a) Lateral view showing the superior temporal gyrus (SupTG). (b) Magnified view highlighting the anatomical relationships between the opercular structures and the underlying insula. The pars triangularis points directly toward the insular apex. Dotted lines indicate the major sulcal boundaries: superior limiting sulcus (yellow), anterior limiting sulcus (blue), and inferior limiting sulcus (red). Surgical removal of these cortical structures exposes the limen insulae and the anterior short gyri of the insula.

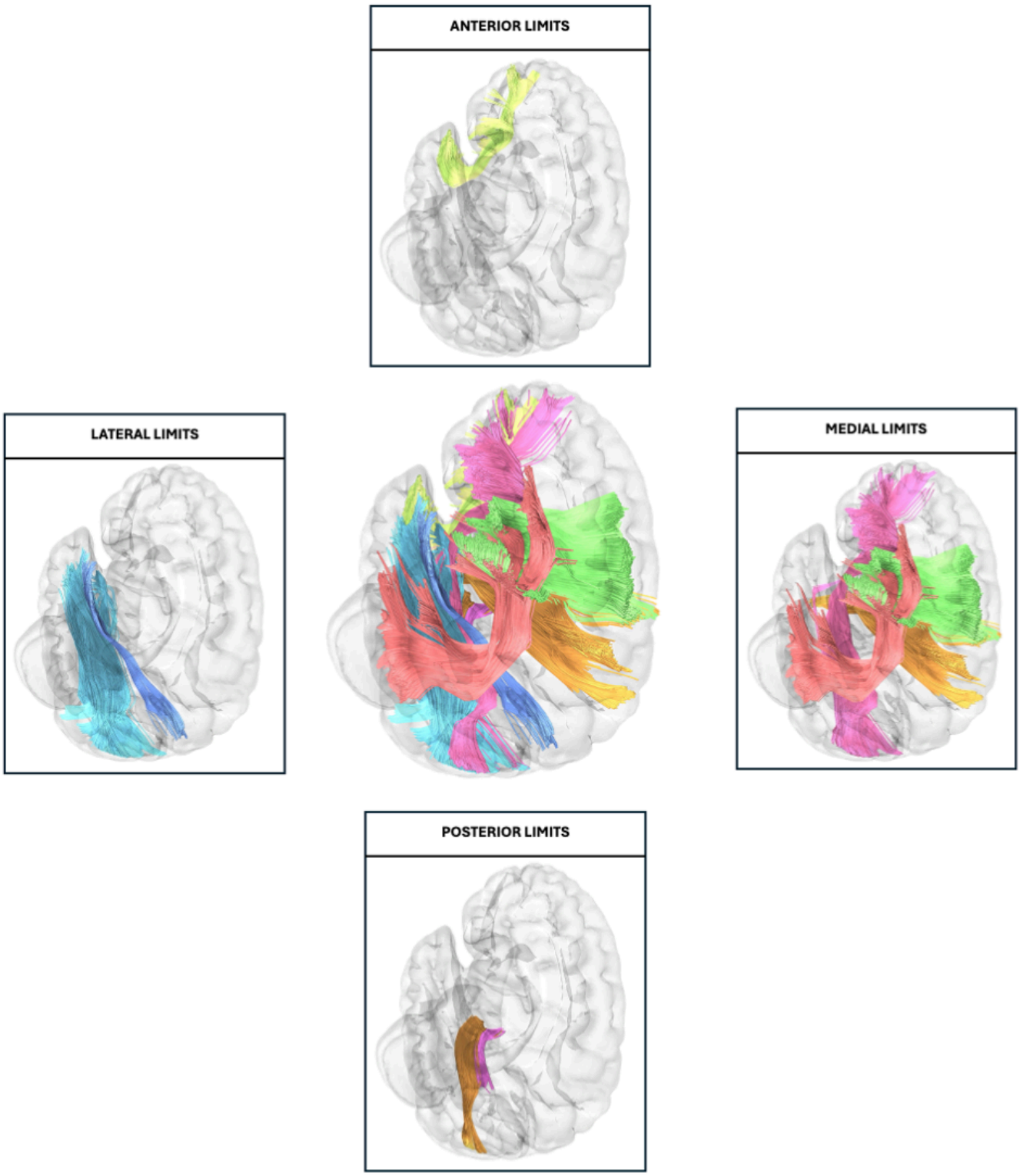


Figure 2

Schematic representation of the subcortical limits of the transopercular transinsular mesotemporal surgical corridor. At the center, a 3D reconstruction of key white matter tracts is shown, corresponding to the left hemisphere and displayed in the surgical position to expose the described corridors. The uncinate fasciculus (UF, yellow) defines the anterior limit; the inferior longitudinal fasciculus (ILF, light blue) and middle longitudinal fasciculus (MdLF, dark blue) define the lateral limits; the inferior fronto-

occipital fasciculus (IFOF, pink), arcuate fasciculus (AF, red), corticospinal tract (CST, orange), and frontal aslant tract (FAT, green) constitute the medial limits; and the optic radiations (orange) mark the posterior limit.

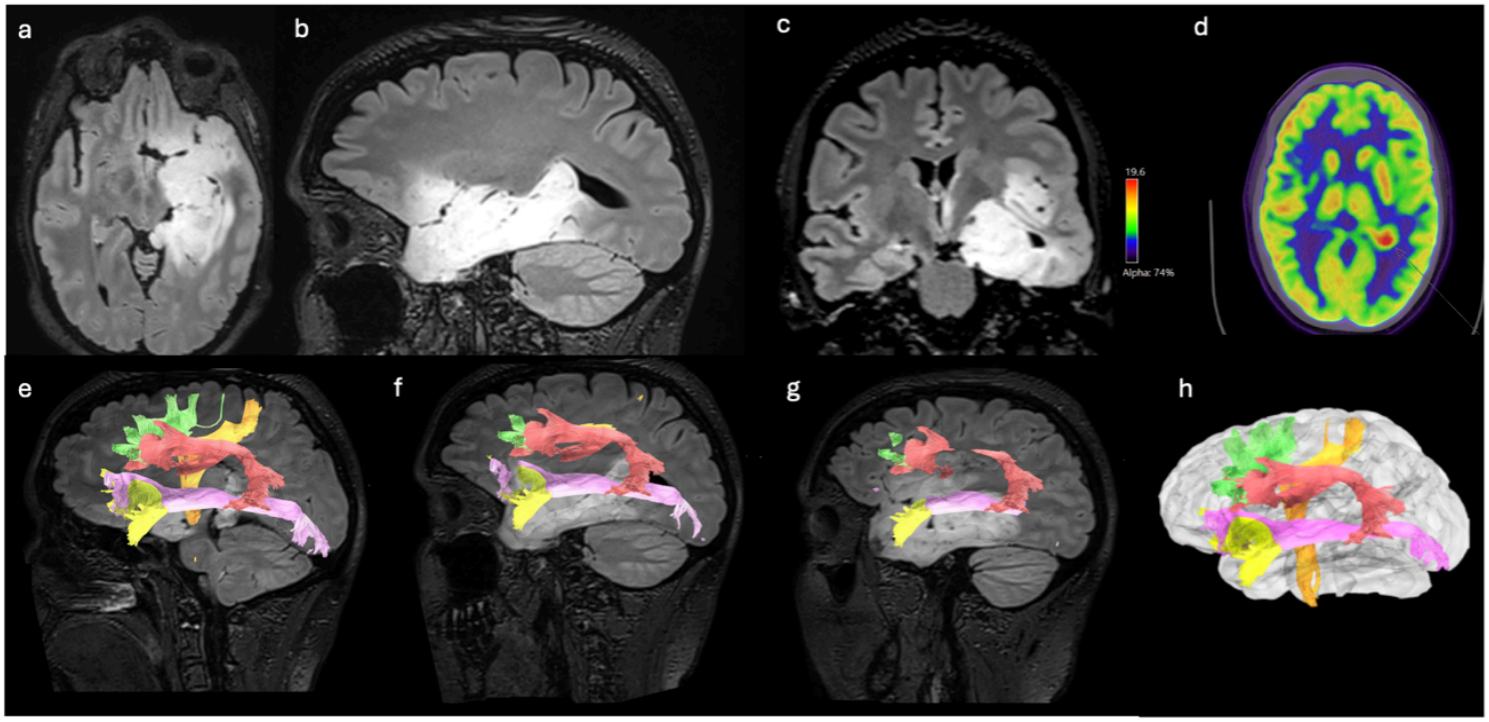


Figure 3

Preoperative MRI, PET imaging, and tractography-based planning of the surgical corridor. (a–c) Axial (a), sagittal (b), and coronal (c) FLAIR MRI sequences showing a left temporo-insular lesion with extension into the occipital lobe and frontal operculum. The lesion appears hyperintense, non-enhancing, and consistent with a low-grade glioma. (d) Preoperative 11C-methionine PET scan showing a hypermetabolic focus in the left mesial temporal region, indicating increased metabolic activity in the uncus and hippocampal head, suggestive of high cellular turnover in these areas. (e–g) Sagittal MRI slices with overlay of tractography reconstructions displaying the spatial relationship between the lesion and surrounding white matter tracts. The series progresses from medial (e) to lateral (g), highlighting the planned subcortical surgical trajectory and its proximity to key associative fibers. (h) Three-dimensional tract reconstruction using DSI Studio showing the arcuate fasciculus, uncinate fasciculus, inferior fronto-occipital fasciculus, and other major tracts. This visualization supports anatomical understanding and guides functional preservation during resection.

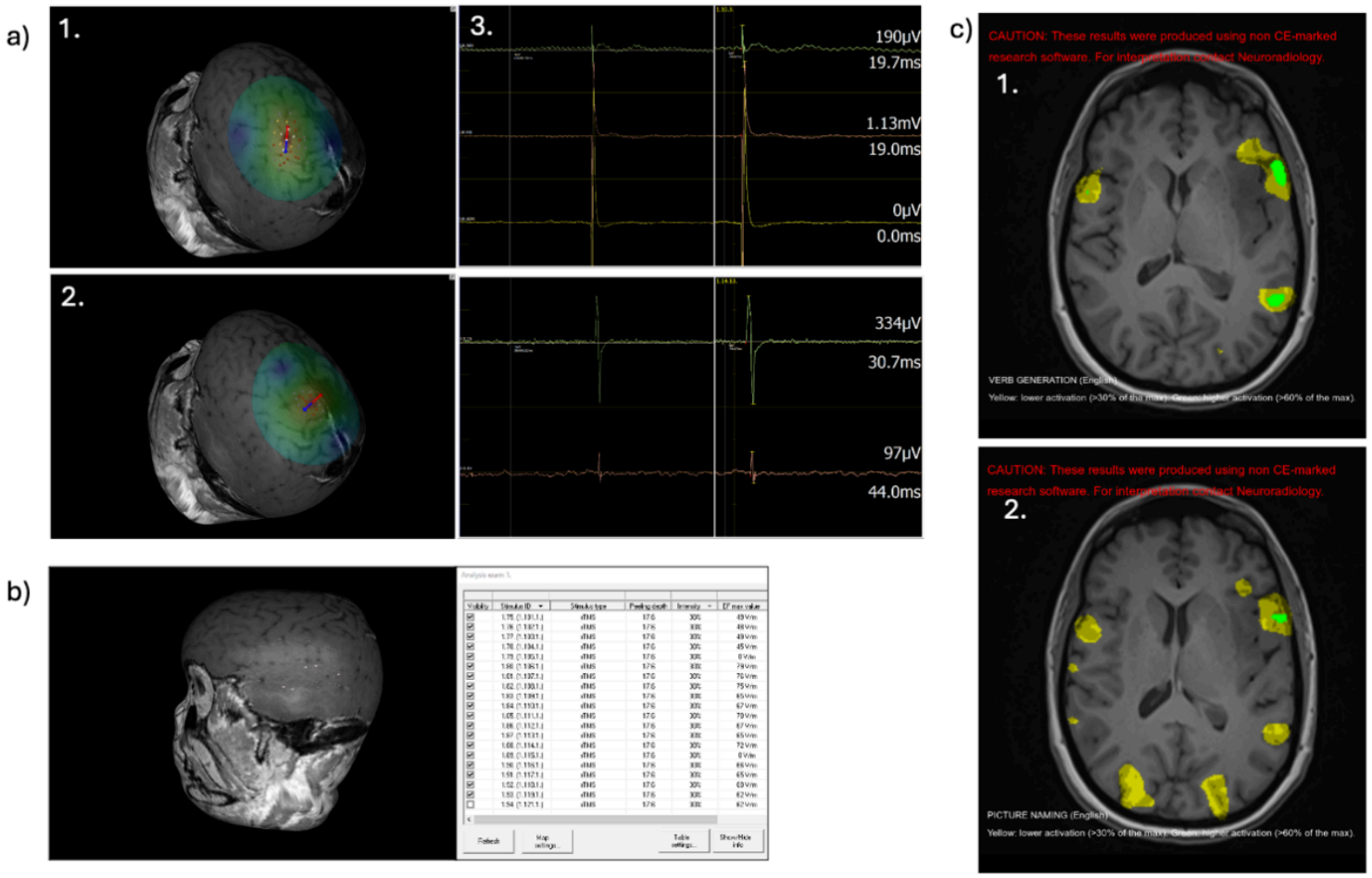


Figure 4

Functional pre-surgery mapping of the patient. We used the Navigated Transcranial Magnetic Stimulation (nTMS) with the eXimia system (Nexstim, Helsinki, Finland) and a figure-of-8 coil. The green circle indicates the estimated electric field over the hemisphere during the stimulation. Red and blue arrows mark cortical hotspots explored during the nTMS stimulation. a) Motor mapping of the left-primary motor cortex by stimulating the 1) upper and 2) lower limbs. 3) Motor Evoked Potentials (MEPs) were recorded using electromyography from the abductor pollicis brevis (APB), first dorsal interosseous (FDI), and abductor digiti minimi (ADM) muscles for the hand; from the tibialis anterior (TA) and the abductor hallucis (AH) muscles for the leg. b) The language mapping via the Repetitive nTMS. The patient's RMT was 30%; we stimulated 5Hz/5pulse trains with 0 delay. The grey and white dots on the left temporal cortex showed the mapped and perturbated hotspot. c) Functional MRI to detect 1) the verb generation and 2) the picture naming areas, where lower activation (>30% of the max) are indicated by yellow areas and an higher activation (>60% of the max) by the green one.

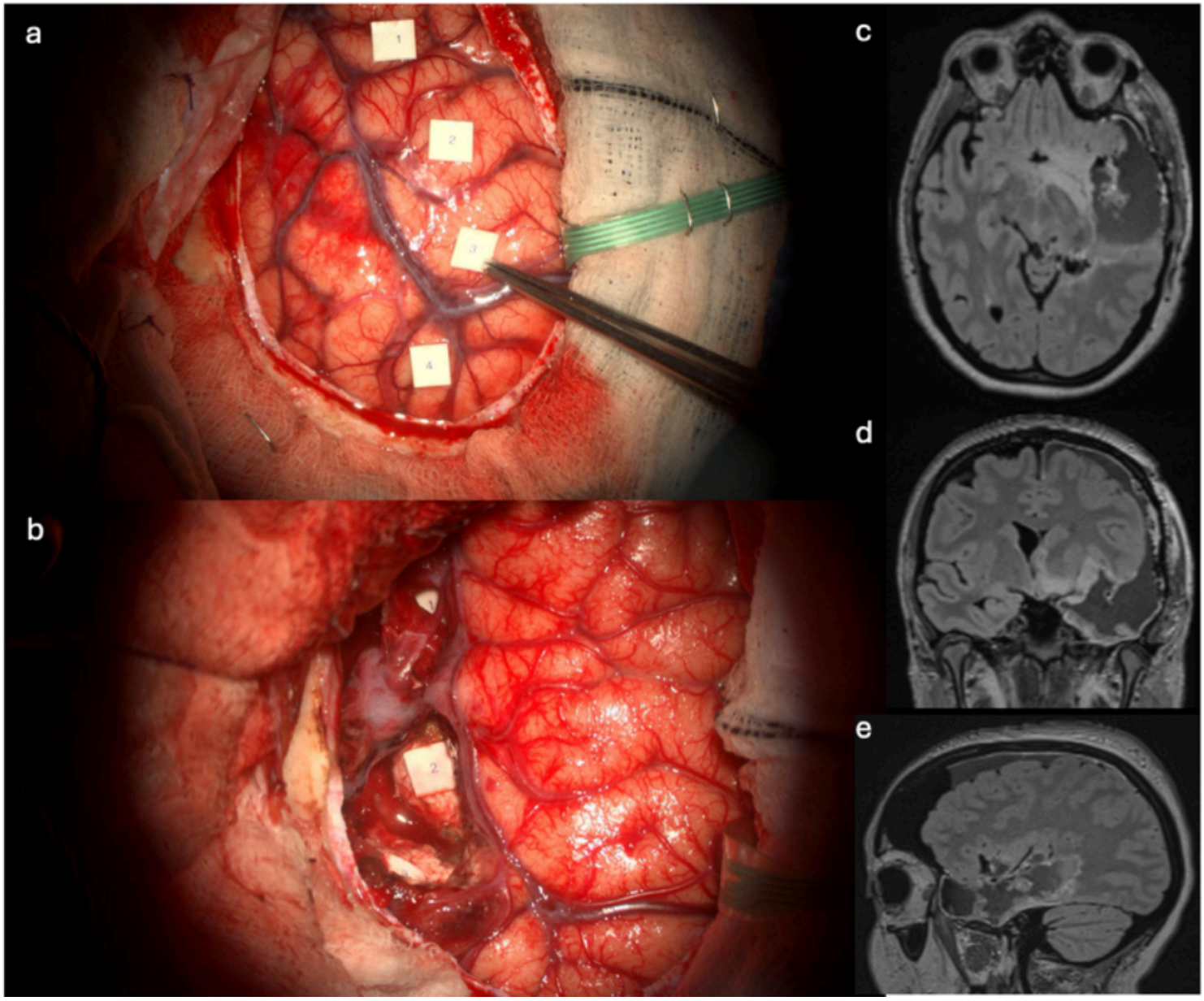


Figure 5

Intraoperative cortical mapping and postoperative imaging. (a) Intraoperative view during cortical stimulation mapping. Number 1 corresponds to speech arrest at 3.5 mA using low-frequency stimulation (LFS) at the convergence of the fronto-aslant tract (FAT) and arcuate fasciculus (AF) in the inferior frontal gyrus. Numbers 2 and 3represent phonetic errors, while number 4 corresponds to semantic errors. Cortical mapping was performed at 3.5 mA LFS following the identification of speech arrest. (b) Subpial dissection through the anterior opercular window, exposing the anterior insula and M3 branches of the MCA. (c–e) Postoperative axial (c), coronal (d), and sagittal (e) T1-weighted MRI sequences showing the resection cavity and preservation of adjacent cortical structures.

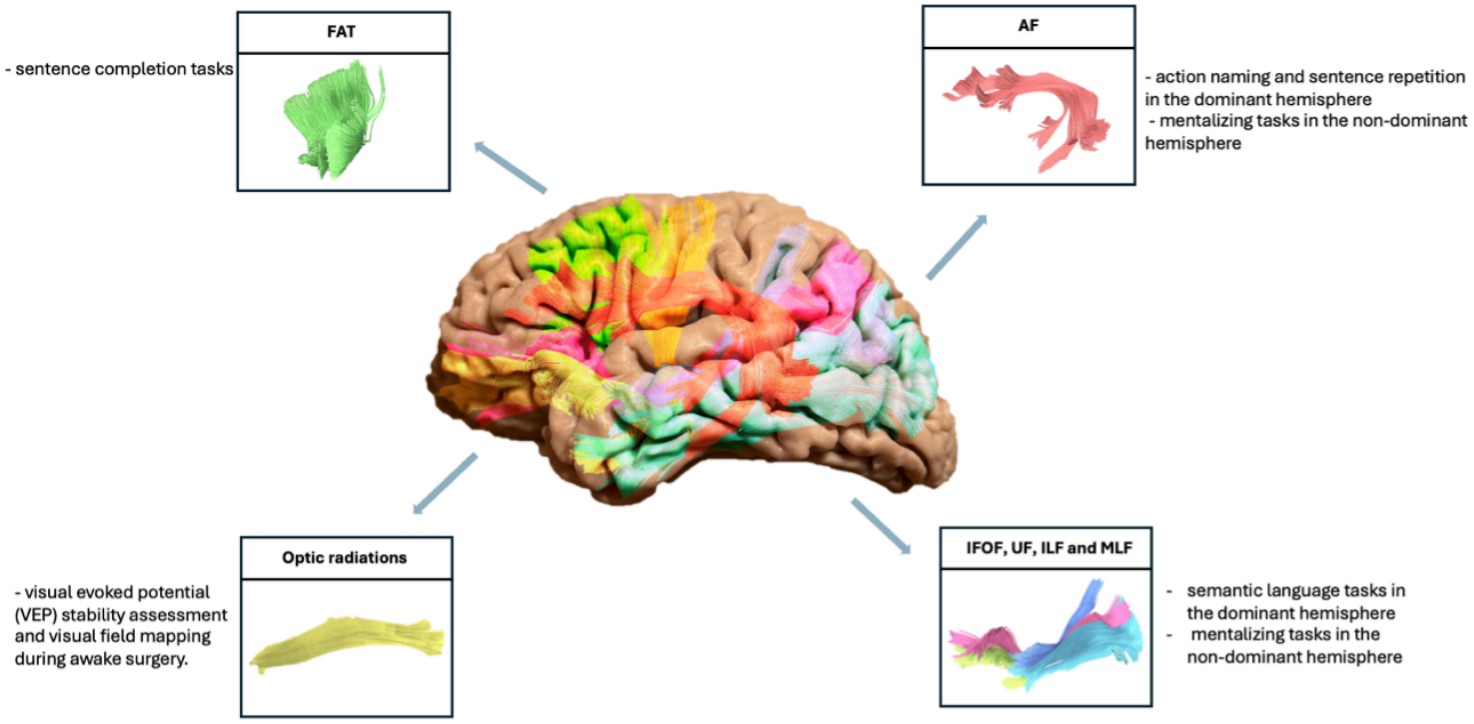


Figure 6

Tasks to be performed for monitoring the relevant tracts during subcortical dissection. Subcortical mapping was conducted using a combined methodology, initiating with high-frequency stimulation (250 Hz) for dynamic screening and identification of subcortical structures, followed by low-frequency bipolar stimulation (60 Hz) for confirmatory functional testing during task execution.

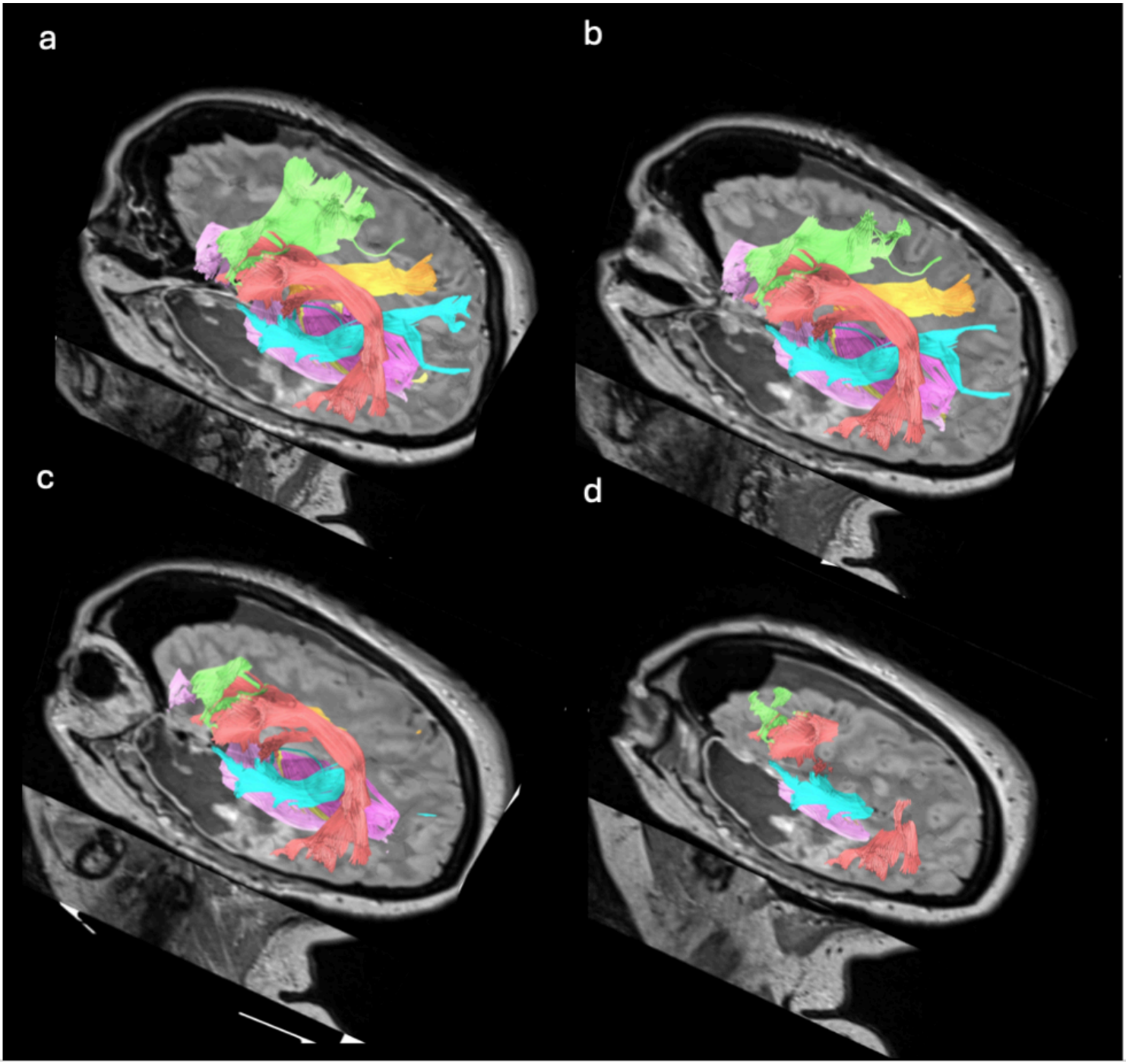


Figure 7

Postoperative MRI with 3D tractography reconstruction illustrating the resection cavity in relation to surrounding white matter tracts. FLAIR sequences (a–d) show axial and sagittal planes from a postoperative MRI, overlaid with 3D reconstructions of key subcortical tracts to assess their relationship to the surgical cavity. The images progress from medial (a) to lateral (d) in the sagittal plane, allowing visualization of the anatomical preservation of associative fiber bundles such as the arcuate fasciculus, uncinate fasciculus, inferior fronto-occipital fasciculus, corticospinal tract and inferior longitudinal fasciculus. The surgical corridor is visualized extending through the anterior insula toward the mesial temporal structures.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Video1.mp4