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Integrating Neuromodulation-Induced Prehabilitation and Laser Interstitial Thermal Therapy in a Multimodal Treatment Strategy for Recurrent Glioblastoma: A Case Report

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Case Report

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Additional Declarations: Competing interest reported. A.P.L. is listed as an inventor on several issued and pending patents on the real-time integration of transcranial magnetic stimulation with electroencephalography and magnetic resonance imaging, and applications of non-invasive brain stimulation in various neurological disorders; as well as digital biomarkers of cognition and digital assessments for early diagnosis of dementia. A.P.L. serves on the scientific advisory boards for Neuroelectrics, Magstim Inc., TetraNeuron, Skin2Neuron, MedRhythms, Bitbrain, and AscenZion. He is co-founder of TI solutions and co-founder and chief medical officer of Linus Health. None of these companies have any interest in or have contributed to the present work. The remaining authors declare that they have no competing interests

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Integrating Neuromodulation-Induced Prehabilitation and Laser Interstitial Thermal Therapy in a Multimodal Treatment Strategy for Recurrent Glioblastoma: A Case Report

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Abstract

Motor-eloquent glioblastoma forces a trade-off between resection extent and functional preservation. Neuromodulation-induced prehabilitation (NIP), combining low-frequency rTMS with task-specific training, has been reported before resection but, to our knowledge, not before ablation. We report a 44-year-old man with recurrent right frontal motor-eloquent glioblastoma who underwent two NIP cycles, preceding open resection and, at second recurrence, MRI-guided laser interstitial thermal therapy (MRIgLITT). After NIP-Cycle 1, fMRI and navigated TMS showed redistribution of the left-hand representation away from tumor-adjacent cortex; after NIP-Cycle 2, activation narrowed to residual networks. MRIgLITT achieved >90% ablation. Reorganizational capacity was preserved but spatially constrained under cumulative load.

Keywords: Prehabilitation, glioblastoma, laser interstitial thermal therapy, neuromodulation, case report

Introduction

Glioblastoma (GBM) is the most common malignant primary brain tumor in adults and, despite multimodal treatment, median overall survival remains 15–18 months with recurrence typically within months [16, 18]. Although supramaximal resection is associated with improved prognosis, tumors in eloquent regions pose substantial functional risks [16].

MRI-guided laser interstitial thermal therapy (MRIgLITT) has gained traction as an alternative to open resection, offering safe, meaningful cytoreduction with lower surgical morbidity while enabling adjuvant therapy [9, 10, 12, 19]. However, periablative inflammation and vasogenic edema may disrupt surrounding networks and cause deficits near eloquent cortex [10, 14].

Prehabilitation aims to optimize functional outcomes before surgery by enhancing physical and cognitive resilience [1, 3, 7, 13]. Neuromodulation-induced prehabilitation (NIP) combines non-invasive brain stimulation with task-specific training to promote adaptive reorganization of at-risk functions before surgery [1, 3–5, 7]. Early reports suggest NIP is feasible and safe in motor- and language-eloquent lesions, but evidence in GBM, in repeated cycles, and before ablative procedures remains scarce [5, 6, 15].

The Prehabilita program (ClinicalTrials.gov, TRN: NCT05844605, Registration date: 3 March 2023) delivers 10–20 sessions, combining inhibitory neuromodulation with motor and/or cognitive training, with MRI, TMS mapping, and clinical, functional, and neuropsychological assessments before and after the program and after surgery [3, 4].

We report a patient with recurrent right frontal GBM involving the primary motor cortex who underwent two NIP cycles combining low-frequency rTMS and intensive motor training, preceding open supramaximal resection at first recurrence and MRIgLITT at second recurrence (Fig. 1). To our knowledge, this is the first longitudinal description of repeated NIP cycles in the same patient and the first application of NIP before a non-resective ablative procedure.

Case Report

Patient Information

A 44-year-old man with no relevant medical history presented in July 2022 with focal motor seizures of the left limbs. MRI revealed a hemorrhagic, ring-enhancing lesion in the right middle frontal gyrus. In August 2022 he underwent supramaximal resection; histopathology confirmed GBM (WHO grade 4, IDH-wildtype, MGMT-unmethylated, EGFR-amplified, CDKN2A-deleted, 1p/19q non-codeleted). A transient left-hand-predominant supplementary motor area (SMA) syndrome resolved completely. Following early local progression, he completed concomitant chemoradiation (September–October 2022) and participated in an immunotherapy trial (NCT05187624) for six months. In May 2023, MRI demonstrated recurrence (11 × 6 × 13 mm) in the surgical bed adjacent to the right motor strip and corticospinal tract (Fig. 2; Online Resource 1). The overall course spanned 26 months, from presentation to death in September 2024 (Fig. 1).

NIP-Cycle 1 and Second Resection

At enrollment (May 2023), the patient presented a mild left-hand fine-motor impairment and specific working-memory manipulation deficit. NIP-Cycle 1 comprised 15 daily sessions over 2 weeks: (i) low-frequency rTMS to the left-hand M1 representation, guided by task-based functional MRI (1600 pulses/session, 1 Hz, 60% resting motor threshold [RMT]); (ii) task-specific motor training immediately after rTMS, to exploit post-stimulation plasticity window; and (iii) aquatic high-intensity interval training (HIIT) (Fig. 3). Assessments were performed before and after the cycle and after surgery (T1-S, T4-S, T6-S; Online Resource 2).

Adherence was complete, with no adverse events. Quality of life (QoL), symptom burden, fatigue, motor function, grip strength, and processing speed improved (Online Resource 2). TMS mapping showed an expanded left-hand representation with posterior displacement of the hotspot away from the tumor. Task-based fMRI (tb-fMRI) showed a broader, more distributed pattern, with the peak shifting to the contralateral precentral cortex (Figs. 2 and 4; Online Resource 3).

In June 2023 he underwent repeat craniotomy with apparent complete supramaximal resection. Transient SMA syndrome, bradylalia, and mild dysarthria resolved before discharge. Histopathology showed predominantly treatment-related changes, focal EGFR amplification (Ki-67 1–5%), consistent with residual GBM on a treatment-modified background. A surgical-site infection required craniotomy revision in July 2023.

NIP-Cycle 2 and MRIgLITT

In May 2024, at second recurrence, the patient was re-enrolled before planned MRIgLITT (Figs. 2 and 5). He presented mild upper-limb-predominant left hemiparesis, left hypoesthesia, dysmetria, SMA syndrome, mild bradypsychia, and executive dysfunction (Online Resource 2). NIP-Cycle 2 comprised 17 twice-daily sessions delivered over 2 weeks. rTMS intensity was reduced from 60% to 39% RMT, with frequency and pulse count unchanged. Training was diversified into cognitively engaging modalities (piano, bimanual manipulation, hand-foot coordination), delivered immediately after rTMS, followed by HIIT (Fig. 3; Online Resource 4).

Tolerability and adherence remained good, without adverse events. Assessments were repeated before and after the cycle (T1-L, T4-L); Bilateral grip strength, reaction times, walking speed, and global QoL improved, whereas fatigue and symptom burden increased and fine dexterity (9HPT), and Karnofsky Performance Status worsened, consistent with advancing right frontal–SMA syndrome (Online Resource 2). fMRI showed a 96% reduction in suprathreshold activation and absent perilesional activation (Fig. 2; Online Resource 3).

MRIgLITT was performed in May 2024 under frame-based stereotaxy, robotic trajectory guidance, placing two parallel laser probes across the enhancing lesion adjacent to the right frontal horn (Fig. 5), under real-time MRI thermometry. Twenty-four-hour MRI indicated >90% ablation, with two residual enhancing foci (≤10 mm) along the ventricular wall beyond the trajectories, and increased perilesional edema without mass effect. The immediate course was uneventful; progressive deterioration followed, and the patient died in September 2024, four months after MRIgLITT.

Discussion

We present a patient with recurrent right frontal motor GBM who underwent two sequential NIP cycles, preceding open supramaximal resection and MRIgLITT for different recurrences.

Four observations emerge: (i) sequential NIP across distinct recurrences is feasible and tolerable, with full adherence and no adverse effects; (ii) prehabilitation-driven neural dynamics may reduce injury risk to critical regions before surgical or ablative interventions; (iii) prehabilitation could be integrated with non-resective cytoreductive procedures; and (iv) reorganizational capacity was preserved across both cycles.

We propose the concept of plasticity load as the cumulative demand placed on the brain's reorganizational capacity by tumor infiltration, surgical disruption, adjuvant treatment, and repeated neuromodulatory intervention [5, 8, 11]. We distinguish this from reorganizational capacity (the residual ability of the system to reconfigure) and reorganizational topography (the spatial distribution across which that reconfiguration is expressed). Plasticity load may thus constrain or redirect reorganization as the substrate becomes progressively compromised [8, 11].

First recurrence: cortical reorganization and surgical outcome

NIP-Cycle 1 was completed without adverse events, consistent with the safety reported for NIP and navigated rTMS in neurosurgical patients [4–6, 17]. Because GBM disrupts local and network-level plasticity through infiltration, edema, and treatment-related injury [8, 11], redistributing function away from the tumor before surgery may widen the margin of resection [15]. Apparent complete resection was achieved with preserved motor pathways.

Second recurrence: NIP under cumulative load

By NIP-Cycle 2, the patient had undergone two craniotomies, chemoradiation, and immunotherapy, and presented progressive hemiparesis with MRI-confirmed recurrence; this cycle was nevertheless completed without adverse events, supporting feasibility under advancing disease. The neural response differed qualitatively from NIP-Cycle 1; overall motor-related activation decreased and perilesional activation for distal limb tasks was absent (Fig. 2).

Reducing rTMS intensity to 39% RMT was required in a substrate with altered excitability, which limits direct cross-cycle comparison. Nevertheless, a measurable reorganizational response persisted, suggesting that capacity is not exhausted after a single procedure but becomes spatially constrained under accumulating load. If NIP can shift critical representations away from tissue at risk, it may reduce dependence on vulnerable perilesional regions [2–4, 7]. This rationale extends to MRIgLITT and other procedures expected to induce substantial perilesional edema. The >90% ablation achieved here is comparable with benchmarks for recurrent GBM in the LAANTERN Registry [9, 12].

Patient Perspective

The patient described being “prepared to die, but not to lose autonomy”, a distinction that guided his engagement. Reflecting on enrollment, he explained: “For me, participating in this

program was seeing the light, and I did everything I could to make the surgery as successful as possible". After NIP-Cycle 2, he reported: "The result was wonderful". On completing the final Prehabilita protocol: "I want to live".

Limitations

This single case permits no causal inference. The absence of a control condition, multiple concurrent interventions, and mixed functional findings preclude attributing changes specifically to NIP. Post-NIP-Cycle 2 TMS mapping was not obtained because of clinical deterioration. Neural analyses were descriptive, and fMRI may be confounded by neurovascular uncoupling, edema, and acquisition variability. Plasticity load remains a qualitative, unquantified construct.

Conclusion

Repeated NIP was feasible and well tolerated before both open resection and MRIgLITT in recurrent eloquent GBM, and serial fMRI changes were consistent with preserved but progressively constrained motor-network reorganization. NIP may extend to non-resective ablative procedures; prospective longitudinal studies are needed.

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Statements and Declarations

Competing interests

A.P.L. is listed as an inventor on several issued and pending patents on the real-time integration of transcranial magnetic stimulation with electroencephalography and magnetic resonance imaging, and applications of non-invasive brain stimulation in various neurological disorders; as well as digital biomarkers of cognition and digital assessments for early diagnosis of dementia. A.P.L. serves on the scientific advisory boards for Neuroelectrics, Magstim Inc., TetraNeuron, Skin2Neuron, MedRhythms, Bitbrain, and AscenZion. He is co-founder of TI solutions and co-founder and chief medical officer of Linus Health. None of these companies have any interest in or have contributed to the present work. The remaining authors declare that they have no competing interests.

Ethics approval

The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Research Ethical Committee of Fundació Unió Catalana d'Hospitals (approval number: CEI 21/65, version 1, 13/07/2021).

Consent to participate

Informed consent was obtained from this patient and all patients included in the Prehabilita study.

Consent to publish

The authors affirm that the patient provided informed consent for the publication of the details and images included in this case report; written consent for publication was obtained before his death.

Authors Contributions

E.B.O. and N.B.B. contributed to investigation, formal analysis, data curation, visualization, and writing – original draft, writing – review & editing. J.M.T., G.V.M., K.A.P. and A.P.L. contributed to conceptualization, methodology, investigation, resources, and writing – review & editing. L.B., S.D.G. and A.R.V. contributed to investigation and data curation. K.A.P. and G.V.M. contributed to project administration and supervision. R.P.A. and D.B.F. contributed to investigation and writing – review & editing. A.L.J., M.V.G. and J.C.F. contributed to methodology and investigation. All authors read and approved the final manuscript.

Data availability

To protect participant confidentiality and in accordance with ethical approval and informed consent, the datasets from this study are not publicly accessible. Access is restricted and may be granted upon reasonable request. For further details, please contact the corresponding author.

Declaration of generative AI in scientific writing

During the preparation of this work the authors used Claude (Opus 5.5, Anthropic) to support language editing and rephrasing for clarity. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article. No content, data, analysis, figure, or reference was generated by an AI tool. All factual content, clinical data, neuroimaging interpretation, and references were authored, verified, and approved by the human co-authors.

Reporting Statement

This case report was prepared in accordance with the CARE guidelines for reporting case reports. A completed CARE 2013 checklist is provided as Online Resource 5. Abbreviations are listed as Online Resource 6.

References

1. Barcia JA, Sanz A, González-Hidalgo M, de Las Heras C, Alonso-Lera P, Díaz P et al (2012) rTMS stimulation to induce plastic changes at the language motor area in a patient with a left recidivant brain tumor affecting Broca's area. Neurocase 18(2):132–138

2. Ben Dor N, Raffa G, Scibilia A, Espahbodinea S, Garcia C, La Torre D et al (2025) Motor network pre-habilitation by low-frequency repetitive transcranial magnetic stimulation. A proof-of-concept. Acta Neurochir (Wien) 167(1):182

3. Boccuni L, Abellaneda-Pérez K, Martín-Fernández J, Leno-Colorado D, Roca-Ventura A, Prats Bisbe A et al (2023) Neuromodulation-induced prehabilitation to leverage neuroplasticity before brain tumor surgery: a single-cohort feasibility trial protocol. Front Neurol 14:1243857

4. Boccuni L, Roca-Ventura A, Buloz-Osorio E, Leno-Colorado D, Delgado-Gallén S, Cabello-Toscano M et al (2024) Non-invasive prehabilitation to foster widespread fMRI cortical reorganization before brain tumor surgery: lessons from a case series. J Neurooncol 170(1):185–198

5. Boccuni L, Roca-Ventura A, Buloz-Osorio E, Leno-Colorado D, Martín-Fernández J, Cabello-Toscano M et al (2024) Exploring the neural basis of non-invasive prehabilitation in brain tumour patients: an fMRI-based case report of language network plasticity. Front Oncol 14:1390542

6. Brault-Boixader N, Roca-Ventura A, Delgado-Gallén S, Buloz-Osorio E, Boccuni L, Laredo C et al (2026) Non-invasive prehabilitation before neurosurgery modifies the topography of the language production network without compromising function. Neuroimage 339:122185

7. Dadario NB, Young IM, Zhang X, Teo C, Doyen S, Sughrue ME (2022) Prehabilitation and rehabilitation using data-driven, parcel-guided transcranial magnetic stimulation treatment for brain tumor surgery: proof of concept case report. Brain Netw Modul 1(1):48–56

8. Duffau H (2020) Can non-invasive brain stimulation be considered to facilitate reoperation for low-grade glioma relapse by eliciting neuroplasticity? Front Neurol 11:582489

9. de Groot JF, Kim AH, Prabhu S, Rao G, Laxton AW, Fecci PE et al (2022) Efficacy of laser interstitial thermal therapy (LITT) for newly diagnosed and recurrent *IDH* wild-type glioblastoma. Neuro-Oncol Adv 4(1):vdac040

10. Holste KG, Orringer DA (2019) Laser interstitial thermal therapy. Neuro-Oncol Adv 2(1):vdz035

11. Krishna S, Choudhury A, Keough MB, Seo K, Ni L, Kakaizada S et al (2023) Glioblastoma remodelling of human neural circuits decreases survival. Nature 617(7961):599–607

12. Leuthardt EC, Chiang V, Hadjipanayis CG, Landazuri P, Placantonakis DG, Abram SR et al (2026) Laser Interstitial Thermal Therapy for Brain Tumors: A Prospective Multicenter Analysis of Patients From the LAANTERN Study. J Clin Oncol 44(27):2634–2644

13. McIsaac DI, Kidd G, Gillis C, Branje K, Al-Bayati M, Baxi A et al (2025) Relative efficacy of prehabilitation interventions and their components: systematic review with network and component network meta-analyses of randomised controlled trials. BMJ 388:e081164

14. Montemurro N, Anania Y, Cagnazzo F, Perrini P (2020) Survival outcomes in patients with recurrent glioblastoma treated with Laser Interstitial Thermal Therapy (LITT): A systematic review. Clin Neurol Neurosurg 195:105942

15. Rivera-Rivera PA, Rios-Lago M, Sanchez-Casarrubios S, Salazar O, Yus M, González-Hidalgo M et al (2017) Cortical plasticity catalyzed by prehabilitation enables extensive resection of brain tumors in eloquent areas. J Neurosurg 126(4):1323–1333

16. Roh TH, Kim SH (2023) Supramaximal Resection for Glioblastoma: Redefining the Extent of Resection Criteria and Its Impact on Survival. Brain Tumor Res Treat 11(3):166–172

17. Tarapore PE, Picht T, Bulubas L, Shin Y, Kulchytska N, Meyer B et al (2016) Safety and tolerability of navigated TMS for preoperative mapping in neurosurgical patients. Clin Neurophysiol 127(3):1895–1900

18. Wen PY, Weller M, Lee EQ, Alexander BM, Barnholtz-Sloan JS, Barthel FP et al (2020) Glioblastoma in adults: a Society for Neuro-Oncology (SNO) and European Society of Neuro-Oncology (EANO) consensus review on current management and future directions. Neuro-Oncol 22(8):1073–1113

19. Zhao X, Li R, Guo Y, Wan H, Zhou D (2024) Laser interstitial thermal therapy for recurrent glioblastomas: a systematic review and meta-analysis. Neurosurg Rev 47(1):159

Figure Captions

Fig. 1 Clinical timeline of tumor recurrences, prehabilitation cycles, and interventions (July 2022–September 2024)

Fig. 2 Serial neuroimaging across both NIP cycles. Left, post-contrast T1-weighted MRI; right, tb-fMRI motor activation maps (red, pre-intervention; green, post-intervention; blue, post-surgery); radiological convention. Post-ablative fMRI was not obtained because of clinical deterioration

Fig. 3 Task-specific motor and physical training. (a) Piano-based sequential finger training; (b) fine-motor object manipulation; (c) visuomotor reaction-time training; (d) upper-limb coordination; (e) aquatic HIIT

Fig. 4 Navigated TMS motor mapping of the left-hand representation before and after NIP-Cycle 1

Fig. 5 MRIgLITT dual-probe placement. (a) Intraoperative view; (b) coronal MRI with the planned parallel trajectories

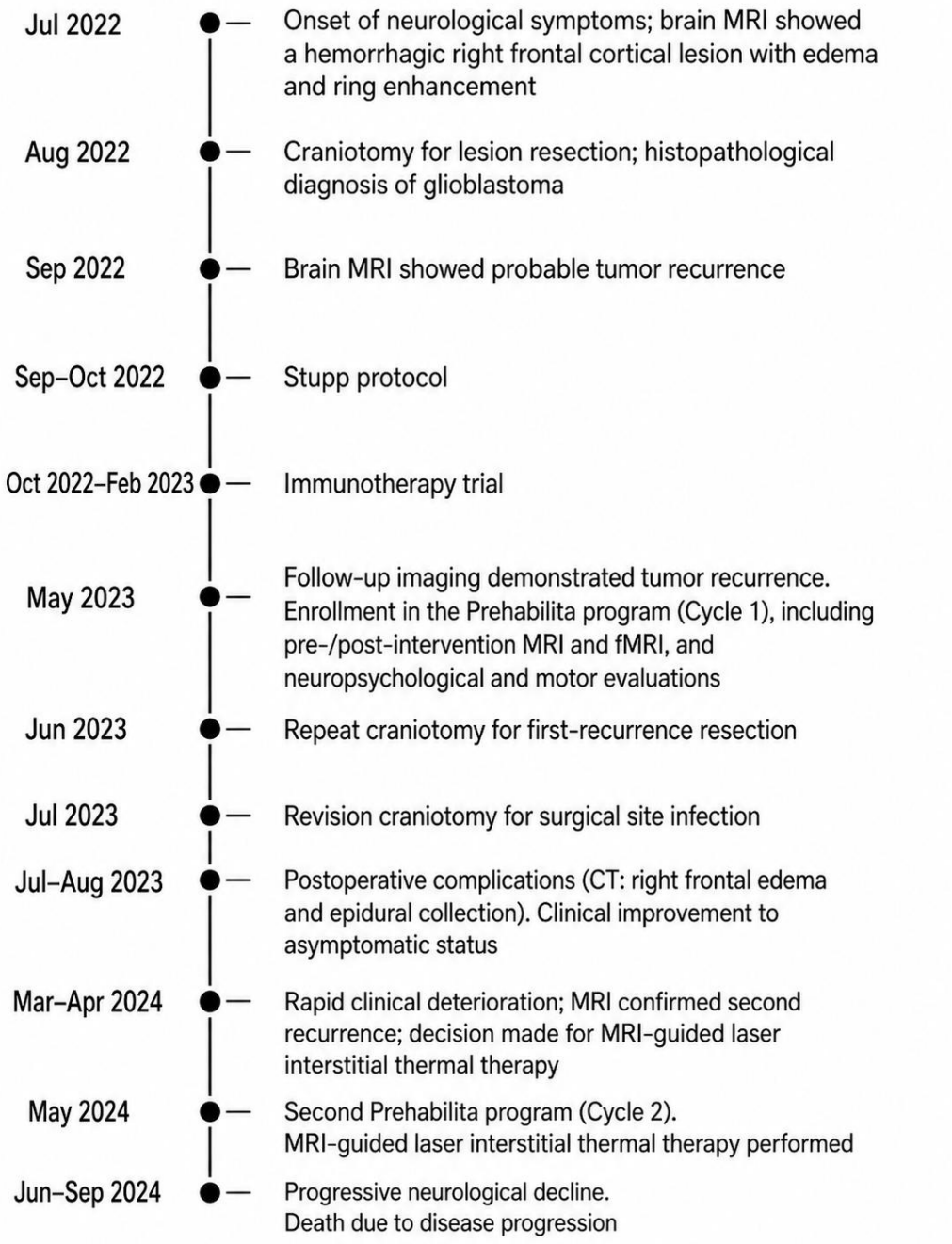


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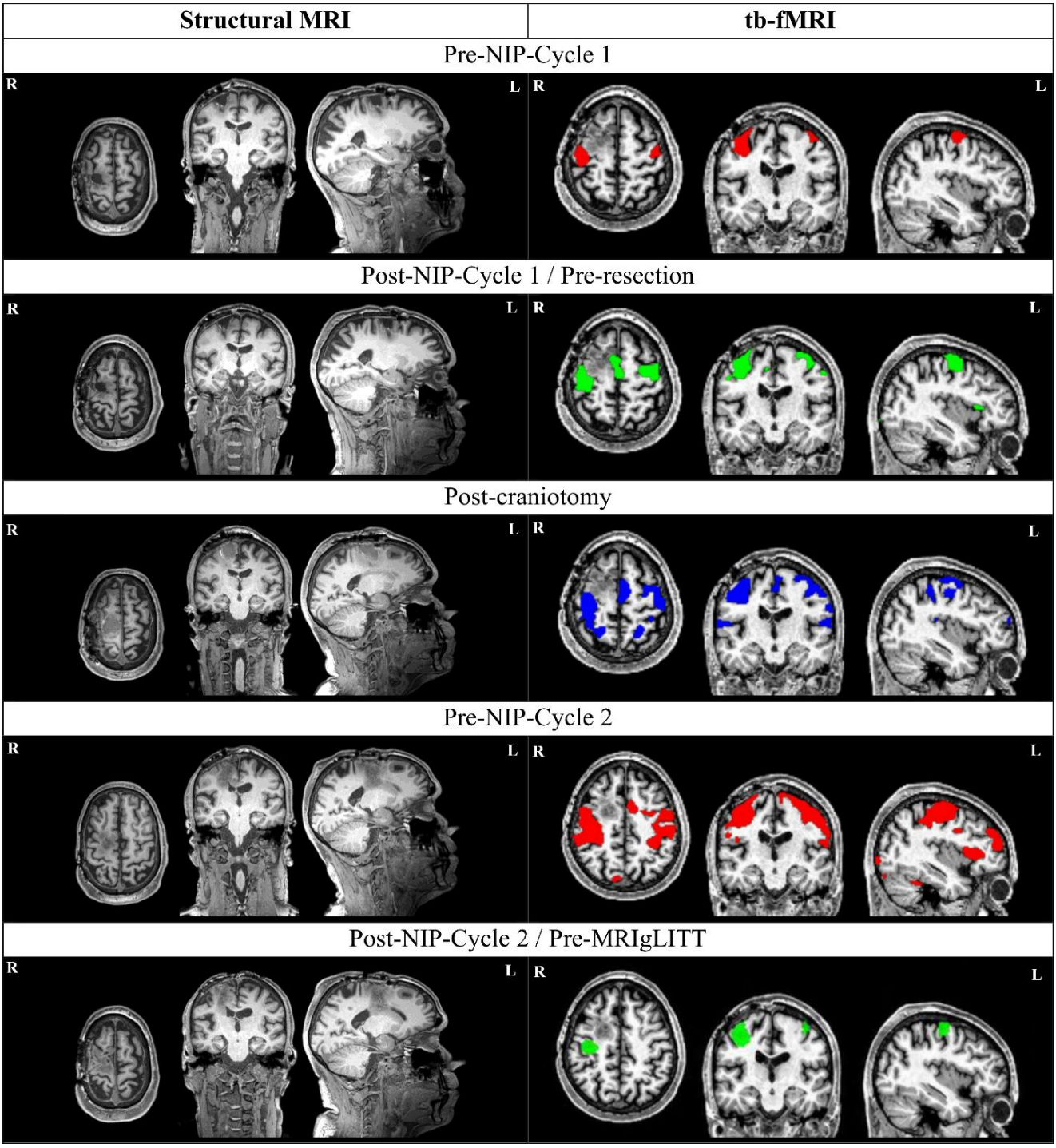


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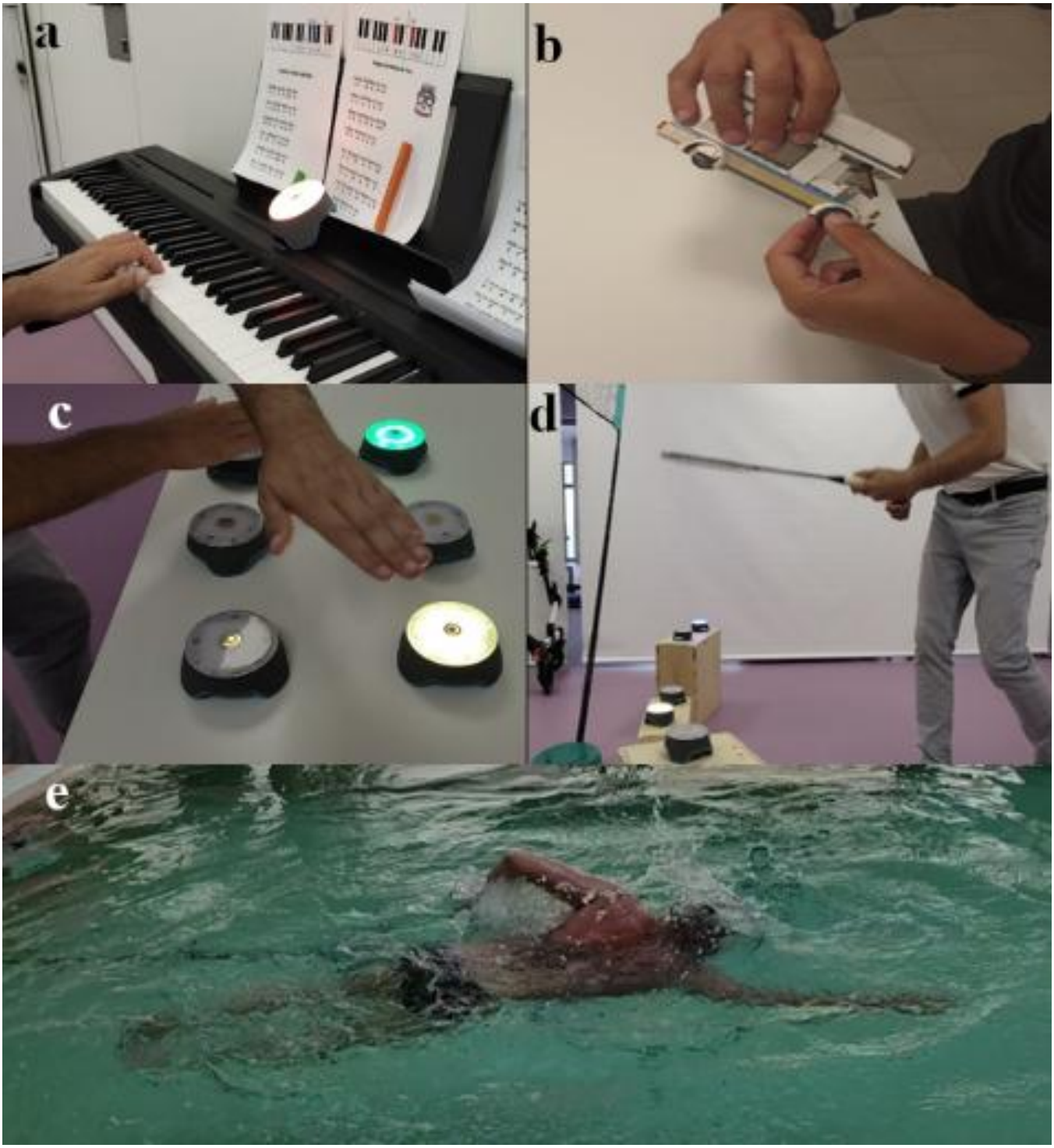


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363

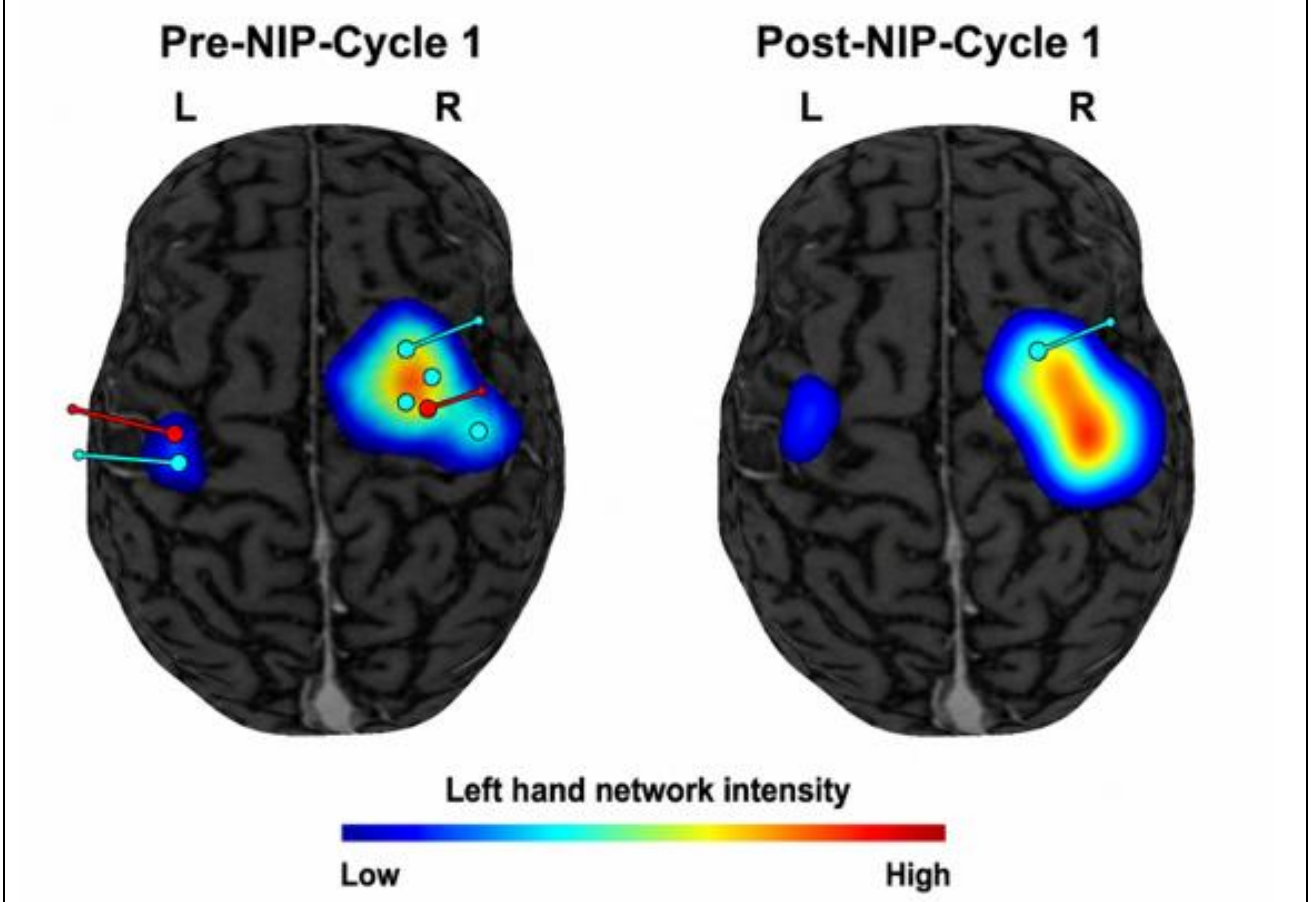


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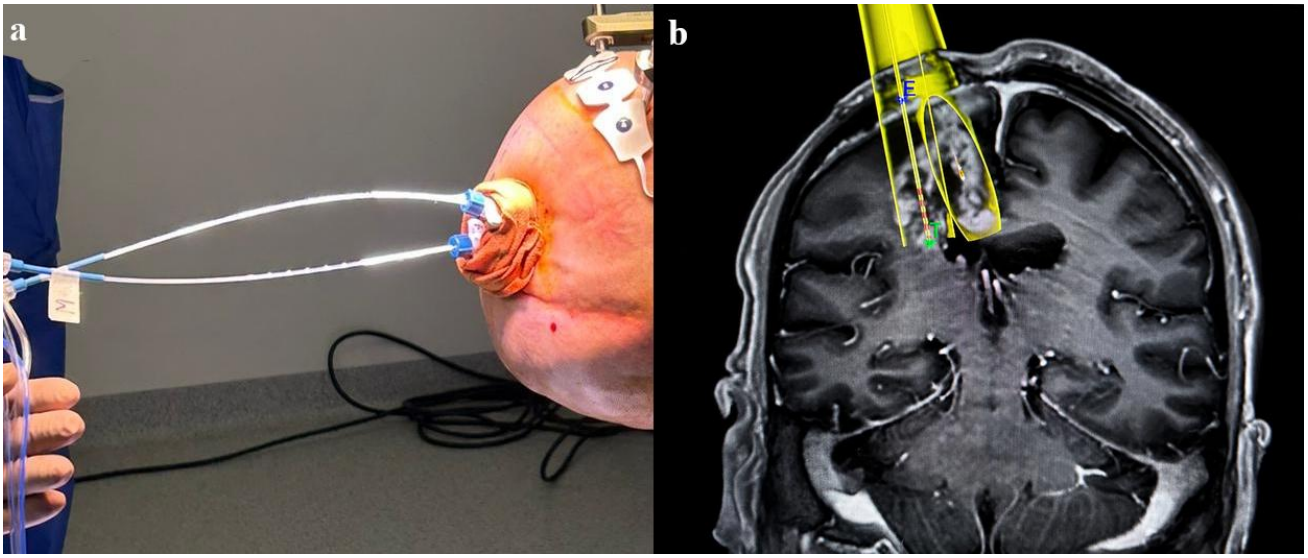


Fig. 5 MRIgLITT dual-probe placement. (a) Intraoperative view; (b) coronal MRI with the planned parallel trajectories

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