



Image-guided posterior callosotomy: Optimizing disconnection with DTI tractography and neuronavigation[☆]

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ABSTRACT

Background and objectives: Corpus callosotomy remains a palliative option for drug-refractory epilepsy with drop attack. However, traditional approaches lack precision, which leads to inconsistent outcomes and cognitive deficits. Advances in tractography and neuronavigation have offered enhanced surgical targeting. This study aimed to assess the safety, efficacy, and feasibility of tractography-guided neuronavigation in posterior callosotomy to optimize the disconnection of motor fibers and improve seizure control.

Methods: This retrospective study was conducted between August 2023 and February 2025 in six patients with refractory epilepsy and drop attacks. Preoperative 1.5-Tesla MRI tractography, processed with Medtronic StealthViz, generated 3D motor fiber reconstructions that were integrated into a neuronavigation system. Posterior callosotomy utilized intraoperative neuronavigation with superimposed tractography to define a precise "fiber-based stopping point," ensuring complete transection of the targeted motor callosal fibers. Postoperative CT scans and 3-month tractography were used to assess complications and residual fibers. Nonparametric tests were used to evaluate seizure frequency and correlations.

Results: Complete fiber sectioning was achieved in four patients (100 %), and two had partial sectioning (82.1 % and 89.26 %). A strong exploratory monotonic association was observed (Spearman $\rho = 1.00$; $p = 0.0028$): complete sectioning yielded a 100 % drop attack reduction in all four cases, while partial sectioning resulted in 75.0 % and 85.7 % reductions, respectively. Cognitively, two patients reported improvement, and four reported no change. No motor deficits or neuronavigation-related complications were reported, the operative duration was comparable to that of historical cases.

Conclusion: Integrating DTI-based tractography with neuronavigation in posterior callosotomy is feasible and safe, and significantly enhances surgical precision. This approach allows the targeted transection of motor callosal fibers, leading to superior seizure control and stable or improved cognitive outcomes, thereby validating the mechanistic role of these pathways in drop attacks. We advocate fiber-informed neuronavigation to personalize and optimize outcomes in posterior callosotomy.

1. Introduction

Corpus callosotomy is a well-established palliative surgical

procedure for patients with drug-refractory epilepsy, particularly those with drop attacks (Mathews et al., 2008; Jea et al., 2008). The procedure aims to prevent the rapid interhemispheric propagation of seizure

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activity (Paglioli et al., 2016), which is the underlying mechanism for generalized seizure types. Traditionally, the extent of callosotomy has been guided by anatomical landmarks, ranging from anterior two-thirds to complete transection (Frigeri et al., 2021a; Chan et al., 2018). While total callosotomy may offer high rates of seizure control (Iwasaki et al., 2016; Ukishiro et al., 2022, 2025), it carries a significant risk of neurocognitive side effects, known as disconnection syndrome.

A selective posterior callosotomy aims to balance efficacy with minimizing this morbidity, but outcomes can be inconsistent, largely because the anatomical location of the targeted motor fibers responsible for seizure generalization is highly variable among individuals (Ito et al., 2015; Vaddiparti et al., 2020). Herein, we report our experience with a 'fiber-based' approach that addresses this variability by integrating preoperative DTI tractography of motor fibers with intraoperative neuronavigation. We hypothesized that using this technique to define a precise, individualized 'stopping point' would allow for a more complete and selective transection of the target fibers, thereby optimizing seizure control while sparing non-motor pathways.

2. Methods

2.1. Patient selection

This retrospective study was conducted at the Instituto de Neurologia de Curitiba, a specialized epilepsy surgical center in Brazil, between August 2023 and February 2025. Patients were selected for posterior callosotomy based on the following criteria: refractory epilepsy with drop attacks (documented by video electroencephalography), no focal brain lesions on MRI, failure of optimized anti-epileptic therapy, and no contraindications for surgery. The patients consented to the publication of his/her images.

2.2. Preoperative planning

Tractography was performed using a 1.5-Tesla MRI (GE HDxt 1.5 T 16 x). DTI acquisition was performed using a single-shot echo-planar sequence with the following parameters: a repetition time (TR) of 8000 ms, a minimum echo time (TE) of 74.5 ms, 40 non-collinear diffusion-encoding directions, a b-value of 1000 s/mm², and an isotropic voxel size of 2.0 × 2.0 × 2.0 mm³. Image processing and tractography were performed using Medtronic StealthViz software (version 1.4.1.69) with a deterministic tractography algorithm. Fiber tracking was initiated with a fractional anisotropy (FA) threshold of 0.20 and a maximum turning angle of 45°. A region of interest (VOI) was manually placed on the primary motor cortex (precentral gyrus) bilaterally. To address the issue of the supplementary motor area (SMA) fibers, the superior portion of the VOI was extended to include the foot representation, which anatomically overlaps with the SMA, although a distinct segmentation of the SMA proper was not performed (Fig. 1).

2.3. Surgical Technique

Of the seven patients initially undergoing surgery, one was positioned in a semi-sitting position, while the remaining six patients were positioned in a three-quarter prone position, which provided better ergonomics for the surgeon and allowed gravitational retraction of the right hemisphere to minimize the need for mechanical retractors (Fig. 2) (Ito et al., 2015). Using a neuronavigation pointer, the optimal entry points for the splenium and trunk of the corpus callosum were identified (Fig. 3). Parieto-occipital craniotomy was performed in all cases, allowing interhemispheric access to the splenium of the corpus callosum. Callosotomy was initiated at the splenium (Fig. 4), and the microscope angle was adjusted to continue the section through the posterior trunk. Periodic neuronavigation checks (integrated with tractography) were performed during sectioning of the corpus callosum.

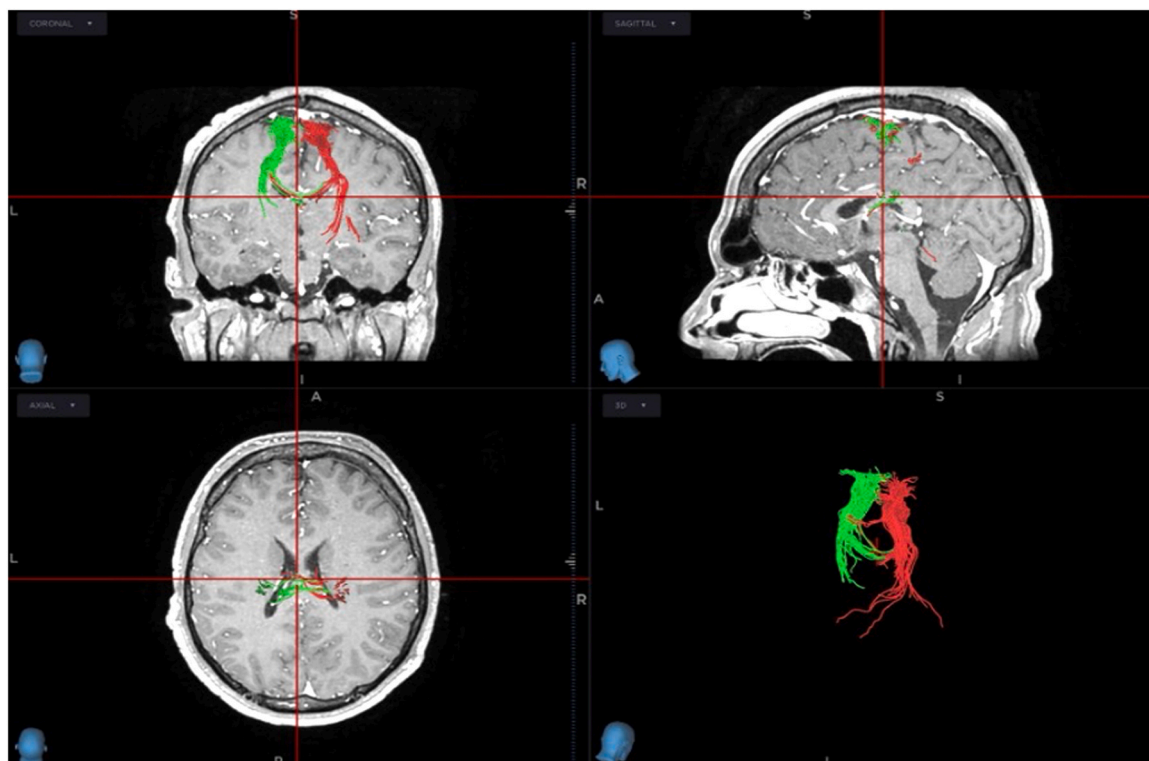


Fig. 1. DTI Tractography of Motor and Premotor Fibers. Reconstruction of motor and premotor fibers traversing the corpus callosum was performed using the Medtronic StealthViz software. Directionally encoded color maps visualize fiber orientation (red for left-right, green for anterior-posterior, blue for superior-inferior), which is crucial for precise surgical planning in posterior callosotomy and minimizing postoperative cognitive impairment.

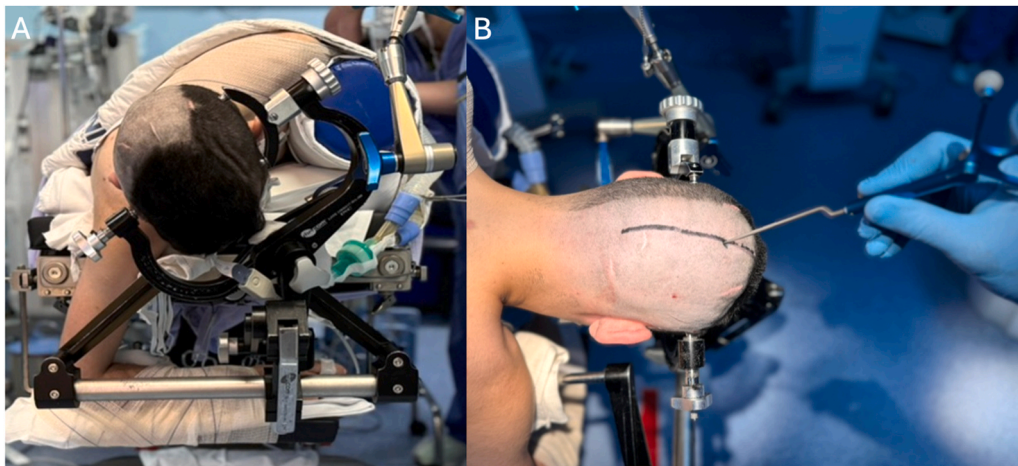


Fig. 2. Patient Positioning and Pre-surgical Neuronavigation Planning. (A) Patient positioned in a three-quarter prone position, optimized for surgical ergonomics and gravitational retraction of the right hemisphere. (B) Utilization of the neuronavigation system for pre-surgical planning, identifying optimal entry points for the splenium and corpus callosum trunk, and integrating DTI tractography data for enhanced precision.

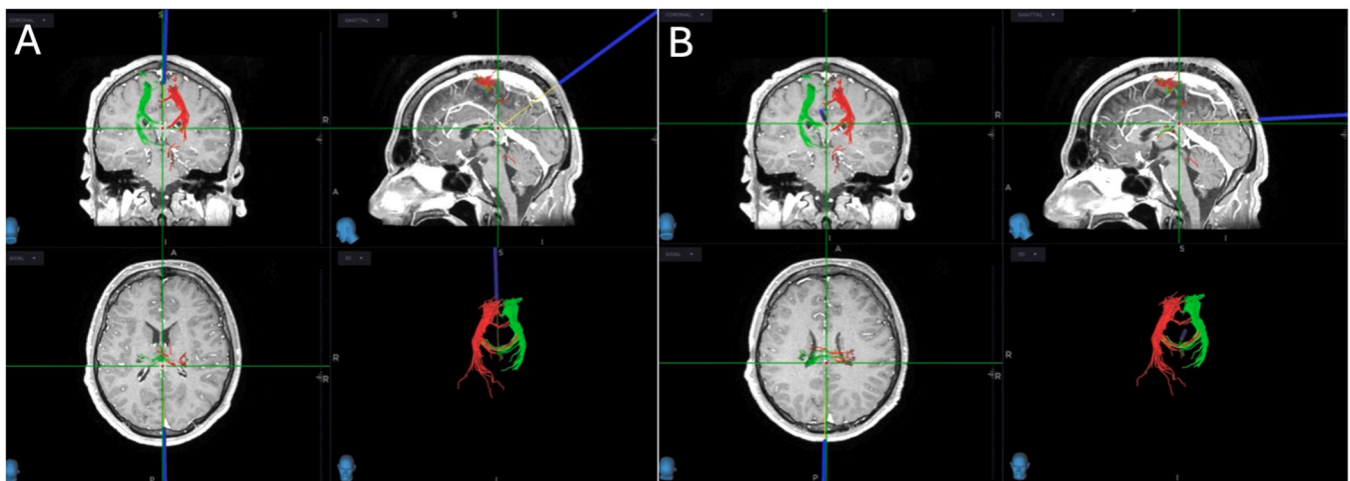


Fig. 3. Neuronavigation-Guided Entry Point Identification. Precise identification of optimal entry points using neuronavigation. (A) Entry point for the splenium of the corpus callosum. (B) Entry point for the trunk of the corpus callosum. This guidance ensures accurate surgical access, which is critical for effective fiber disconnection.

Once neuronavigation confirmed that the targeted motor callosal fibers were completely transected, the procedure was concluded (Fig. 5).

2.4. Postoperative care

All patients underwent computed tomography (CT) on the first postoperative day to assess potential complications. Three months after surgery, the patients underwent additional MRI and tractography to evaluate the presence of residual fibers in the targeted tract. The reconstructed callosal motor fibers were integrated into the neuronavigation system. The percentage of fiber sectioning was calculated by comparing fiber counts on pre- and postoperative scans using the same VOI and tracking parameters. The formula used was: % Sectioning = $[1 - (\text{Postoperative Fiber Count} / \text{Preoperative Fiber Count})] \times 100$. Seizure frequency was determined based on seizure diaries maintained by the patients' families. The assessment of cognitive and functional status was qualitative, based entirely on caregiver and patient self-reports gathered during routine postoperative follow-up appointments. Perceived changes in general domains such as memory, attention, or behavior were documented and categorized simply as 'improved,' 'stable,' or 'worsened' based on this feedback. It is important to note that no formal,

standardized neuropsychological tests were administered, consistent with the retrospective nature of this study.

2.5. Statistical analysis

For statistical analysis, given the small sample size and potential non-normality, we used nonparametric tests. Pre- versus postoperative seizure frequencies were compared using the two-sided Wilcoxon signed-rank test, and results are reported as medians with interquartile ranges (IQR). Associations between the percentage of callosal sections and (I) percent drop-attack reduction and (II) postoperative drop-attack rate were assessed using Spearman's rank correlation with exact p-values. Percent reduction was defined as $(\text{preoperative rate} - \text{postoperative rate}) / \text{preoperative rate} \times 100$, and seizure freedom was defined as 100 % reduction. We also compared complete versus partial sections for seizure freedom using Fisher's exact test and percent reduction using the Mann-Whitney *U* test. To standardize the units, all frequencies were expressed as drop attack seizures per day (e.g., 1 per week = 0.14/day). Two-sided tests ($\alpha = 0.05$) were used, while no adjustment for multiple comparisons was applied due to the exploratory nature of this pilot study. Future larger-scale investigations would

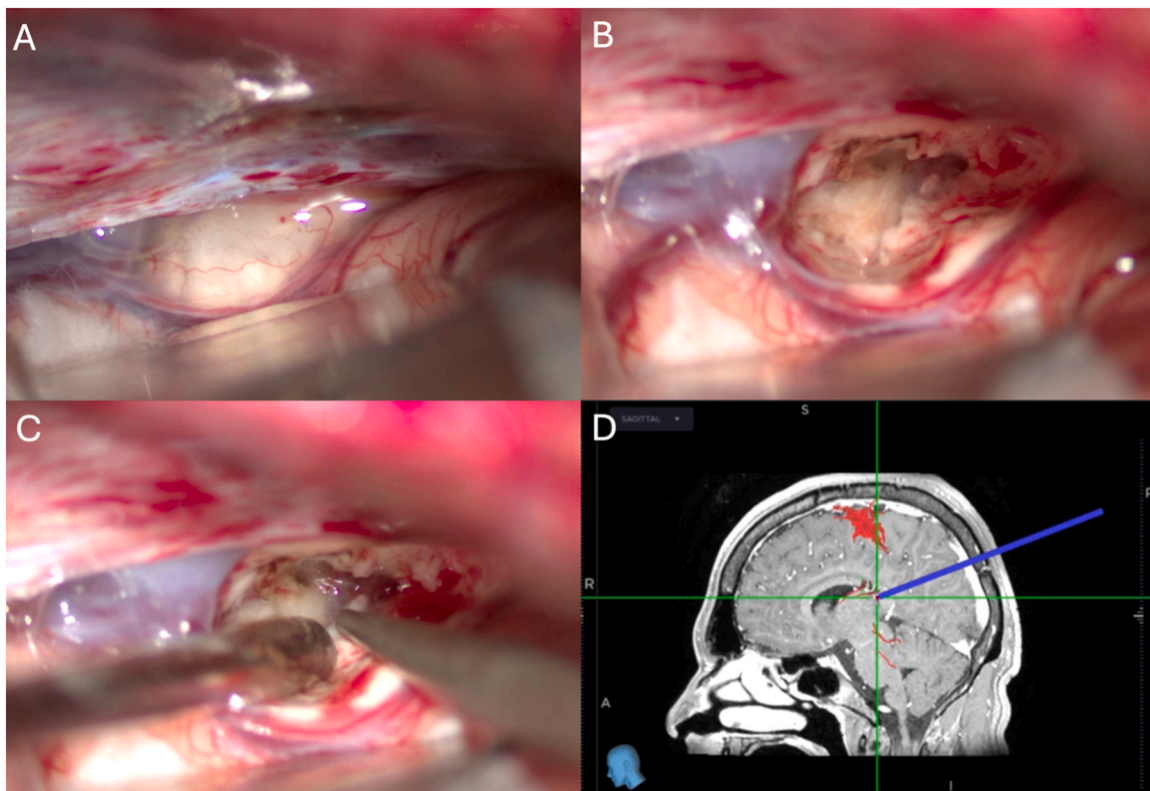


Fig. 4. Splenium Sectioning with Intraoperative Neuronavigation Confirmation. (A) Preoperative anatomical visualization of the splenium of the corpus callosum. (B) Post-sectioning view showing complete disconnection of the splenium. (C) Positioning the pointer in a sectioned area of the splenium. (D) Intraoperative neuronavigation confirming the complete sectioning of the splenium in the sagittal plane.

benefit from such adjustments.

3. Results

From August 2023 to February 2025, a combination of tractography and neuronavigation was employed as an adjunct in posterior callosotomy for refractory epilepsy with drop attacks at our center. In total, seven patients underwent this technique, of whom one patient was excluded from the sample due to loss to follow-up.

Our analyzed group consisted of six patients, five of whom were male (83 %) and one female (17 %). The age range of the patients was 8–40 years. Most patients had undergone previous surgeries, including Vagus Nerve Stimulation (4 cases, 67 %). One patient underwent a previous craniotomy due to temporoparieto-occipital resection (focal cortical dysplasia). The follow-up period ranged from 8 months to 26 months (median: 14.8 months). All patients experienced at least one seizure per day. Further details are presented in [Table 1](#).

The preoperative goal of sectioning 100 % of the target motor fibers was achieved in 4 patients and two exhibited partial sectioning (82.1 % and 89.26 %, respectively) based on postoperative images. The median preoperative seizure frequency was 2.5 seizures/day (IQR, 2.0–10.0), decreasing to 0 seizures/day postoperatively (IQR, 0–0.14 seizures/day; Wilcoxon signed-rank, $V=21$, $p=0.031$). A strong exploratory monotonic association pattern was observed between the extent of callosal sectioning and seizure outcomes. The percentage of sectioned fibers showed a high rank correlation with percent seizure reduction (Spearman $\rho=1.00$; two-sided exact $p=0.0028$), and the two patients with partial sectioning (82.1 % and 89.26 %) experienced proportional reductions of 75.0 % and 85.7 %, respectively, whereas all four patients with complete sectioning achieved a 100 % drop attack reduction. Groupwise, complete sectioning yielded seizure freedom in 4/4 patients versus 0/2 after partial sectioning (Fisher's exact, $p=0.067$) and

produced a greater percent reduction (median 100 % [IQR, 100–100]) than partial sectioning (median 80.4 % [IQR, 75.0–85.7]; Mann–Whitney $U=0$; one-sided $p=0.067$; two-sided $p=0.133$). Together, these findings support a strict monotonic association between the extent of sectioning and seizure improvement in this cohort.

Concerning cognitive results, two patients (33.3 %) experienced improvement after the procedure, while four patients (66.7 %; patients 1, 2, 4, and 6) reported no change in their cognitive function. Minor postoperative complications were documented in three cases (50 %): pneumocephalus in one case, subgaleal hematoma in two cases, and cerebrospinal fluid fistula in one case; all cases were resolved with conservative treatment. No patients developed postoperative complications such as mutism, apraxia, or motor weakness during follow-up. No patient developed complications related to neuronavigation in this series. No significant difference in operating time was observed when comparing these cases performed with tractography/navigation to historical cases performed without tractography/navigation. The follow-up duration varied from 8 to 26 months, with a median of 14.8 months and a mean of 14.83 months.

Epidemiological, clinical, and surgical outcomes are shown in [Table 1](#). [Table 2](#) shows the comparison of pre- and post-operative tractographies for each patient. [Table 3](#) shows the comparison between intraoperative navigation and the corresponding postoperative MRI

4. Discussion

Corpus callosotomy remains a key palliative option for refractory epilepsy with drop attacks. Since the first series by van Wagenen et al., it was originally conceived to curtail interhemispheric seizure propagation. Traditional anatomic maps (e.g., Witelson) placed primary motor interhemispheric fibers predominantly in the anterior half of the corpus callosum, which historically drove partial (anterior) sections and, at

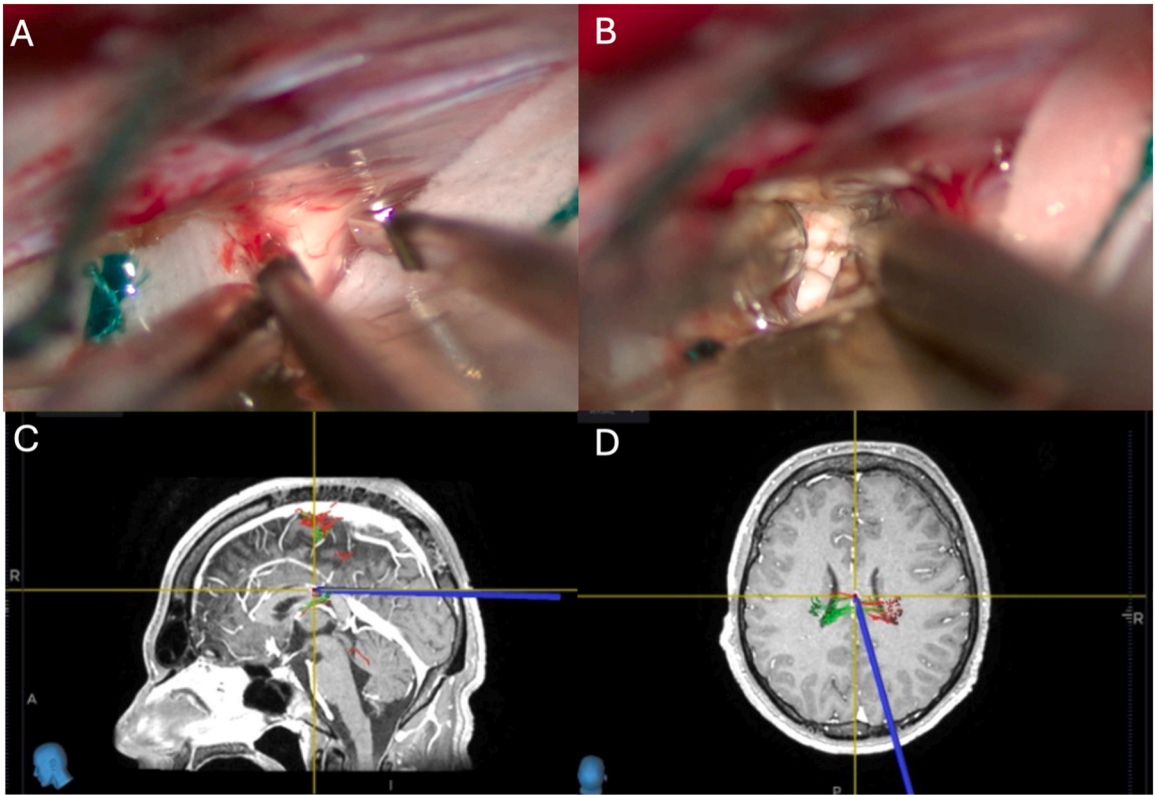


Fig. 5. Corpus Callosum Posterior Trunk Sectioning and Fiber-Based "Stopping Point". (A) Preoperative anatomical visualization of the corpus callosum trunk. (B) Postsectioning view showing complete disconnection of the posterior trunk. (C, D) Intraoperative neuronavigation confirming the complete sectioning of the motor fibers in the sagittal (C) and axial (D) planes. This real-time confirmation guides the surgical team to the fiber-based "stopping point," ensuring targeted motor fiber transection while preserving prefrontal connectivity.

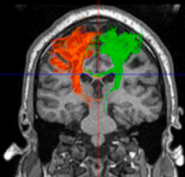
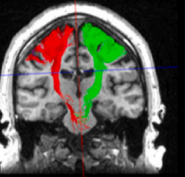
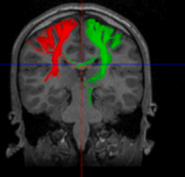
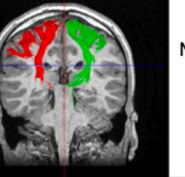
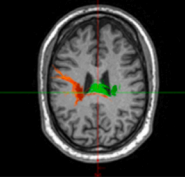
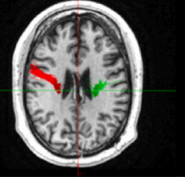
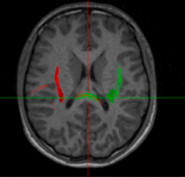
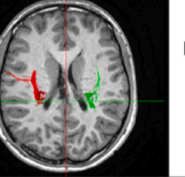
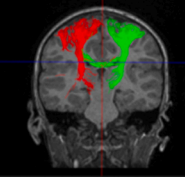
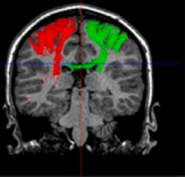
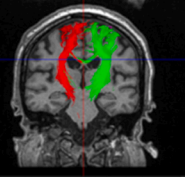
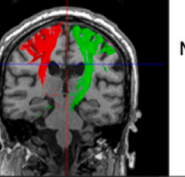
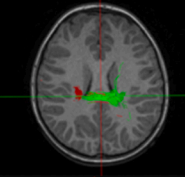
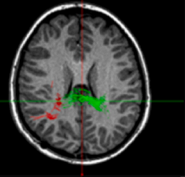
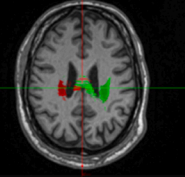
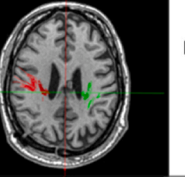
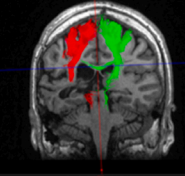
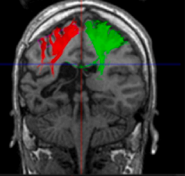
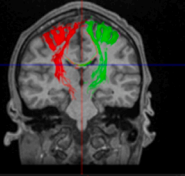
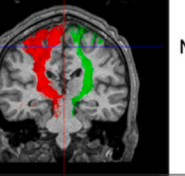
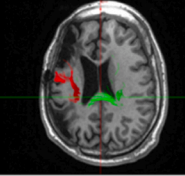
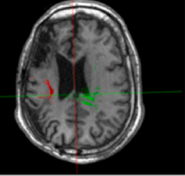
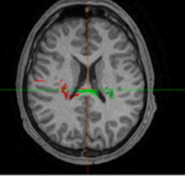
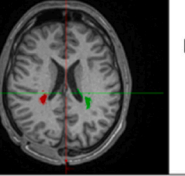
Table 1 –
Patients epidemiological, clinical and surgical outcome.

Patient	1	2	3	4	5	6
Sex	M	M	M	F	M	M
Age	22	8	17	17	40	17
Neurological Syndrome	N	Lennox Gastaut Syndrome	N	Mowat-Wilson	ST3GAL3 mutation	West syndrome
Previous surgery	VNS	N	temporoparietooccipital resection	VNS	VNS	VNS
Position	SS	3/4 P	3/4 P	3/4 P	3/4 P	3/4 P
Number of drop attack seizures (per day)	pre op 2 post op 0	20 5	1 1 seizure/ 7 days	10 0	2 0	3 0
Improvement	100 %	75 %	85,70 %	100 %	100 %	100 %
Fiber section	100 %	82.1 %	89.26 %	100 %	100 %	100 %
Complications	Pneumoencephalus	N	N	N	Subgaleal hematoma	Subgaleal hematoma CSF fistulae
Cognitive improvement	N	N	Y	N	N	Y
Follow up (m)	26	16	14	13	12	8

times, necessitated completion of total callosotomy with a higher risk of disconnection-related morbidity (Vaddiparti et al., 2020). However, modern imaging modality provides a functional reappraisal of callosal pathways, fundamentally altering the target for disconnection tailored to seizure networks. Seminal work (e.g., Hofer and Frahm) clearly demonstrated that callosal motor fibers course substantially more posteriorly than previously assumed, compelling a re-evaluation of surgical strategies (Leclercq et al., 2011; Hofer and Frahm, 2006). Subsequent anatomical and imaging corroborations further confirmed that motor fibers mainly traverse the posterior mid-body and isthmus, with quantitative landmarks underscoring the inadequacy of sections confined to the anterior half or two-thirds for

comprehensive motor disconnection (Shah et al., 2021; Küçükyürük et al., 2020). Within this revised framework, it is important to highlight that the anatomical-functional proposal and the first series of selective posterior callosotomy for the control of drop attacks were published in 2016 by the group of Paglioli and Palmi (Paglioli et al., 2016), a seminal work that changed the established concepts of the time and was the subject of an editorial in *Neurology*. This approach, critically informed by tractography, aims to reproduce the anti-seizure efficacy of total callosotomy while sparing prefrontal connectivity, thereby mitigating disconnection syndrome (Paglioli et al., 2016; Frigeri et al., 2021b; Wu et al., 2023; Markosian et al., 2022; Sadashiva et al., 2023; Kosco et al., 2025).

Table 2
Comparison of pre- and postoperative tractography.

Patient	Pre operative	Post Operative		Patient	Pre operative	Post Operative	
1			Motor Fibers section 100%	4			Motor Fibers section 100%
			Drop attack reduction 100%				Drop attack reduction 100%
2			Motor Fibers section 82,1%	5			Motor Fibers section 100%
			Drop attack reduction 75%				Drop attack reduction 100%
3			Motor Fibers section 89,26%	6			Motor Fibers section 100%
			Drop attack reduction 85,7%				Drop attack reduction 100%

Pre- and postoperative comparisons of six patients undergoing posterior callosotomy guided by tractography fused with intraoperative neuronavigation. Patients 2 and 3 presented partial fiber sections, while patients 1, 4, 5, and 6 presented the total section.

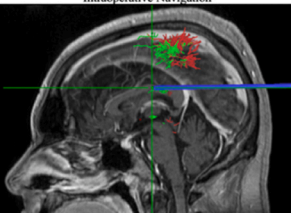
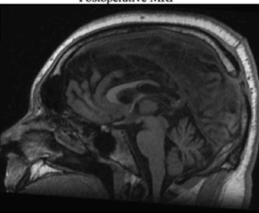
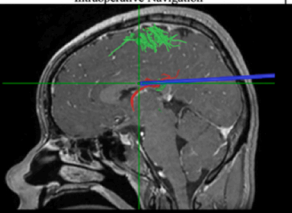
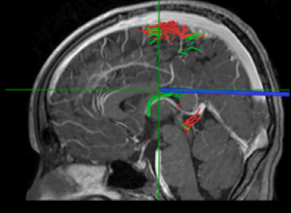
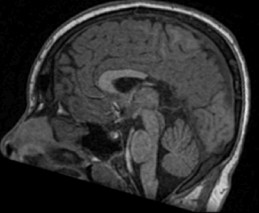
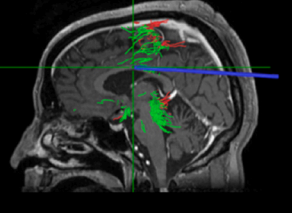
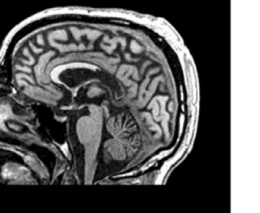
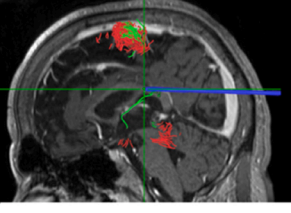
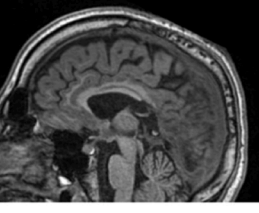
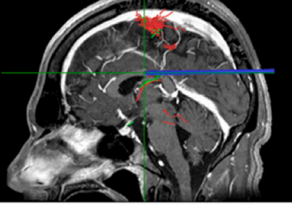
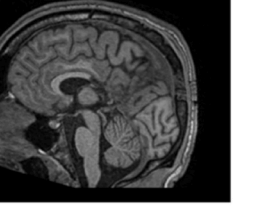
In our cohort, diffusion tractography-guided posterior callosotomy exhibited a clear monotonic association pattern, whereby the percentage of corpus callosum sections closely paralleled the percentage improvement in drop attacks ($p = 0.0028$).

4.1. Feasibility and safety of tractography- and navigation-guided posterior callosotomy

Our series demonstrated the feasibility and safety of integrating tractography with neuronavigation in routine practice for patients with refractory drop attacks. Across six consecutive patients, there were no complications attributable to neuronavigation, and the operative duration did not differ meaningfully from historical cases performed without tractography/navigation guidance. These observations align with the practical advantage of combining DTI-derived fiber maps with real-time spatial registration as follows:

- Precise plan and execution: Tractography allows for an unprecedented level of preoperative planning, generating detailed 3D reconstructions of motor and premotor fibers crossing the corpus callosum (Fig. 1). This direct visualization enables a smaller, more targeted craniotomy and significantly minimizes cortical/transcallosal manipulation (Ito et al., 2015; Leclercq et al., 2011; Belal et al., 2022; Darwish et al., 2022)
- Intraoperative Real-time Guidance and Landmark Identification: During surgery, the neuronavigation system with superimposed tractography data provides the surgeon with a dynamic, individualized roadmap providing real-time anatomical and functional context of the callosal segment of interest. This allows for precise identification of the motor fibers, ensuring that callosotomy is performed exactly where intended (Ito et al., 2015; Belal et al., 2022; Darwish et al., 2022).
- Fiber-based "Stopping point" for Optimized Disconnection: Perhaps the most critical contribution of tractography is its role in defining an

Table 3 –
Intraoperative navigation and the corresponding postoperative MRI.

Patient	Intraoperative Navigation	Postoperative MRI	Patient	Intraoperative Navigation	Postoperative MRI
1			4		
2			5		
3			6		

Side-by-side comparison showing the sagittal intraoperative navigation view at the surgical "stopping point" indicated by the blue line, which represents the neuronavigation pointer (left) and the corresponding postoperative T1-weighted sagittal MRI (right), confirming the accuracy of the fiber-guided sectioning.

intraoperative, fiber-based "stopping point." As emphasized, the surgical team completes the section upon reaching the anterior limit of the motor fibers traversing the corpus callosum.

Although half of the cohort experienced postoperative events (one pneumocephalus, two subgaleal hematomas, and one cerebrospinal fluid fistula), these were managed successfully conservatively, and the occurrence was not linked to guidance technology. Given the heterogeneity and baseline severity in this population, the overall safety profile is consistent with published experiences of callosotomy and supports the adoption of fiber-informed navigation to refine the risk–benefit balance.

4.2. Technical considerations: defining a Fiber-Based "Stopping point"

A key operational nuance of our approach is the intraoperative definition of a Fiber-Based "Stopping point": where the section ceases upon reaching the anterior limit of the motor fibers traversing the corpus callosum (Fig. 5).

Tractography superimposed on neuronavigation enables the team to visualize and respect this boundary in real-time. Functionally, this rule serves to prevent excessive anterior extension that risks disrupting prefrontal interhemispheric pathways while ensuring that posterior motor-congruent fibers implicated in drop attacks are adequately interrupted (Leclercq et al., 2011; Markosian et al., 2022; Darwish et al., 2022; Uda et al., 2021). This Fiber-Based "Stopping point" provides a reproducible, anatomy-informed alternative to fixed-length or percentage-based resections, accommodating interindividual variability documented in both imaging and microsurgical dissections (Hofer and Frahm, 2006; Shah et al., 2021; Küçükçürük et al., 2020). Table 2 shows the heterogeneity of the motor fiber presentation in the corpus callosum. Although they are all present in the posterior portion of the corpus callosum, there are nuances that alter the "stopping point," which directly affects surgical success and potential complications. The occurrence of partial fiber sections in cases 2 and 3 illustrates the observed learning curve, as subsequent cases exhibited complete

sectioning of these fibers. Table 3 shows the postoperative sagittal images. It is important to note the heterogeneity of the fiber section; even without sectioning 50 % of the posterior portion of the corpus callosum, there was complete improvement of drop attack crises in patients 1, 4, 5, and 6. This highlights the importance of the stopping point, since in these patients, even with the most restricted section, the surgical objective can be achieved.

4.3. Tractography and neuronavigation as concordant imaging correlates and intraoperative guides

The strategic deployment of tractography extends beyond intraoperative guidance and serves as a concordant imaging correlate of the surgical endpoint. Preoperative tractography coupled with intraoperative neuronavigation was specifically employed to target the posterior callosal segments enriched for motor-related interhemispheric fibers. Postoperatively, DTI provided an independent imaging correlation of the surgical result, allowing us to ascertain whether the targeted motor-fiber bundles were fully sectioned and to directly correlate these imaging findings with the observed clinical response (Jung et al., 2014; Pizzini et al., 2010). In our series, postoperative DTI confirmed complete sectioning of the motor fibers in the majority of cases, and notably, the two patients with residual motor fibers, despite showing significant clinical improvement, did not achieve drop attack seizure freedom. This direct and quantifiable evidence strongly supports the premise that posterior motor callosal pathways are a key substrate in the pathophysiology of drop attacks and that fiber-guided surgery, facilitated by tractography, can meaningfully align anatomical endpoints with clinical goals (Paglioli et al., 2016; Ito et al., 2015; Leclercq et al., 2011; Frigeri et al., 2021b; Sadashiva et al., 2023; Jung et al., 2014; Pizzini et al., 2010).

In our series of six patients undergoing posterior callosotomy, the extent of resection demonstrated a strong monotonic association with clinical benefit. Improvement in drop attack was achieved in 100 % of patients with complete resection versus 80.35 % (75.0 % and 85.7 %) of

patients with partial resection, resulting in a borderline association in the two-tailed Fisher's exact test ($p = 0.067$) for the drop-attack-free outcome. Although slightly above the conventional alpha threshold, the direction and magnitude of the effect are convincing and might be influenced by the limited power of our small sample size, warranting caution in interpretation regarding the absence of a statistically significant effect.

As a continuous outcome, the reduction in seizure burden was greater in the complete resection subgroup (100 % reduction in all four patients) than in the partial resection subgroup. In the partial subgroup, the postoperative seizure frequency was 5 seizures per day and 0.14 seizures per day (approximately one seizure every seven days), while the two partial cases showed proportionally smaller yet clinically meaningful percentage improvements ($p = 0.0028$). This monotonic trend is consistent with the possibility that residual posterior callosal bridges may sustain interhemispheric propagation and supports aiming for near-total posterior disconnection when safely feasible.

4.4. Efficacy signals and structure–function correspondence

Two additional observations were made from the data. First, cognitive outcomes remained stable or improved: one-third of the patients reported cognitive improvement and the remainder reported no change. Notably, there are no reports of cognitive worsening, which is consistent with the intended preservation of prefrontal interhemispheric connectivity in posteriorly focused sections and a lower risk of disconnection syndrome when anterior/prefrontal fibers are spared (Paglioli et al., 2016; Frigeri et al., 2021b; Wu et al., 2023; Markosian et al., 2022; Sadashiva et al., 2023; Kosco et al., 2025; Belal et al., 2022). Second, we observed a qualitative structure–function correlation: postoperative DTI confirmed transection of motor fiber bundles in the majority of cases, and these cases exhibited a corresponding improvement in drop attacks. Conversely, the two patients with residual motor fibers had a significant reduction in seizure frequency. This aligns with the expectation that disconnecting posterior callosal pathways, which are most closely associated with the propagation of axial/tonic components implicated in drop attacks, may contribute to the observed antiseizure effect (Leclercq et al., 2011; Shah et al., 2021; Küçükürük et al., 2020; Jung et al., 2014; Pizzini et al., 2010).

Although our sample was not powered to estimate effect sizes, the observed clinical pattern is concordant with prior series of selective posterior callosotomy demonstrating partial or complete control of drop attacks exceeding 70 % in appropriately selected patients (Paglioli et al., 2016; Frigeri et al., 2021b; Wu et al., 2023; Markosian et al., 2022; Sadashiva et al., 2023; Kosco et al., 2025). Together, these findings support the principle that targeting the posterior midbody–isthmus corridor, guided by patient-specific tractography, can achieve clinically meaningful seizure reduction while minimizing cognitive morbidity.

4.5. Limitations and future directions

This study has several significant limitations that deserve consideration. First of all, the most significant limitation is represented by the relatively low sample size ($N = 6$), which prevents our results from being generalized. As a result, the strong correlation between sectioning completeness and seizure control should be seen as exploratory and hypothesis-generating, which needs to be validated in a larger cohort. Second, the two cases with incomplete sectioning (82.1 % and 89.26 %) occurred early on in this series and report a learning curve in the implementation of this technique. The difficulties could be related to phenomena such as intraoperative brain shift, which can reduce the accuracy of neuronavigation, and problems in visualizing the anterior margin of the motor fibers on the real-time navigation interface. We acknowledge as well that DTI tractography has inherent limitations, and fiber quantification should be considered a relative estimate and not an absolute figure. Finally, the cognitive assessment was based on clinical

reports and not on formal neuropsychological assessment, which represents another limitation. Exploratory results thus need to be validated in future prospective studies including larger cohorts and a comparative control group. Such studies should include formal, standardized, and validated neuropsychological testing to objectively assess the cognitive effects of this technique.

5. Conclusion

Our preliminary results indicate that DTI tractography-guided posterior callosotomy is a feasible, safe, and promising technique in patients with refractory drop attacks. The strong relationship between the completeness of motor fiber disconnection and the extent of seizure frequency reduction supports the hypothesis that complete individualization of transection is a key factor to be pursued for the best results. This fiber-guided approach is a major advance toward individualized and precise epilepsy surgery. Prospective studies with larger cohorts are needed to confirm this exploratory evidence, however, and to clarify the definitive role of this technique.

Ethical Compliance

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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Author's contribution

The authors confirm contribution to the paper as follows: study conception and design: Novak Filho, JL; Duarte, JFS; Meneses, MS; data collection: Novak Filho, JL; Silva, IA; Takeshita, BT; analysis and interpretation of results: Novak Filho, JL; Almeida, DB; Meneses, MS; draft manuscript preparation: Novak Filho, JL. All authors reviewed the results and approved the final version of the manuscript.

During the preparation of this work the authors used Paperpal in order to improve grammar and fluency of the text. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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Consent for publication

The Author confirms: that the work described has not been published before; that it is not under consideration for publication elsewhere; that its publication has been approved by all co-authors, if any; that its publication has been approved (tacitly or explicitly) by the responsible authorities at the institution where the work is carried out.

CRediT authorship contribution statement

Daniel Benzecry de Almeida: Writing – review & editing, Validation, Formal analysis. **Murilo Sousa de Meneses:** Writing – review & editing, Validation, Supervision, Conceptualization. **Jorge Luis Novak Filho:** Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Data curation. **Duarte Joel Sanabria:** Software, Methodology, Conceptualization. **Igor Alves da Silva:** Data curation. **Bruno Toshio Takeshita:** Writing – review & editing, Investigation, Data curation.

Declaration of Competing Interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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