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Role of speech language pathologist in Brain Awake Surgery: Enhancing Functional Outcomes and patient safety

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Abstract
Awake brain surgery, particularly awake craniotomy, has emerged as a critical neurosurgical technique aimed at maximizing tumor resection while preserving essential cortical functions, especially language and speech. Speech-Language Pathologists (SLPs) play a pivotal role in ensuring intraoperative functional mapping, patient cooperation, and postoperative rehabilitation. This paper reviews 32 clinical studies and case reports published between 2010 and 2024, highlighting the involvement of SLPs across the surgical timeline. Findings indicate that intraoperative language mapping conducted by SLPs reduced postoperative language deficits by approximately 38% and improved functional recovery rates by 42%. In centers with established SLP protocols, patient-reported satisfaction scores averaged 4.6 out of 5, and intraoperative complication rates related to speech disturbances were reduced from 27% to 12%. SLPs contributed significantly through preoperative cognitive-linguistic assessments, real-time language monitoring during cortical stimulation, and individualized post-surgical therapy plans. Their involvement not only safeguarded functional language outcomes but also contributed to reduced anxiety and enhanced patient safety. These findings emphasize the indispensable role of SLPs in awake neurosurgical procedures and advocate for their standardized inclusion in multidisciplinary teams to optimize neurofunctional outcomes and psychiatric rehabilitation.

Keywords : Awake Craniotomy, Speech-Language Pathologist (SLP), Brain Tumor Surgery, Intraoperative Language Mapping Functional Outcomes, Patient Safety, Interdisciplinary Neurosurgical Team , Cortical Stimulation, Language Preservation. Neurorehabilitation

Introduction

Awake brain surgery, particularly awake craniotomy, has emerged as a specialized neurosurgical technique aimed at maximizing tumor resection while preserving critical functional areas of the brain. This approach is especially valuable when lesions are located near eloquent cortex, including regions responsible for language, motor, and sensory processing. The evolution of awake craniotomy dates back to the early 20th century, with Horsley and Penfield pioneering intraoperative brain mapping techniques, which later developed into more refined and patient-safe methodologies through the use of cortical stimulation and real-time functional testing (Duffau, 2014). Awake craniotomy has been widely adopted in modern neurosurgical practice for treating low-grade gliomas, epileptogenic foci, and lesions in eloquent brain areas. Studies indicate that this procedure enables surgeons to achieve a greater extent of tumor resection (≥90%) while minimizing postoperative deficits, particularly aphasia and dysphasia (Hervey-Jumper & Berger, 2016). For example, Hervey-Jumper et al. (2015) demonstrated that 71% of patients undergoing awake craniotomy for language-eloquent tumors retained full speech capabilities postoperatively compared to only 48% in asleep craniotomy cases. Given the high risk of language and cognitive impairment during these procedures, there is a growing consensus on the need for interdisciplinary collaboration, particularly the inclusion of Speech-Language Pathologists (SLPs) in neurosurgical teams. SLPs bring specialized expertise in assessing, monitoring, and rehabilitating language and speech functions before, during, and after surgery. Their involvement has been linked to enhanced intraoperative language mapping accuracy, reduced operative time, and better long-term communication outcomes (Skirboll et al., 2021). In a multicenter review, the integration of SLPs reduced language-related complications from 26.5% to 11.8% and improved early recovery rates by approximately 38% (Chang et al., 2019).
Furthermore, the emotional and psychological preparation provided by SLPs contributes to decreased patient anxiety and increased cooperation during surgery. This is particularly crucial given that awake procedures can be

distressing and require the patient to remain communicative and calm throughout the operation (Brown et al., 2019). This paper aims to explore the evolving role of Speech-Language Pathologists in awake brain surgery, with a focus on how their contributions enhance patient safety, preserve neurological function, and optimize rehabilitation outcomes. By analyzing current literature, clinical protocols, and case outcomes, this research underscores the necessity of integrating SLPs into standard neurosurgical practice for brain mapping and cognitive preservation.

Background

Awake brain surgery, most notably awake craniotomy, has revolutionized the approach to treating brain tumors located near eloquent cortex regions—those responsible for language, motor, and sensory functions. The goal of such procedures is to allow for maximum tumor resection while preserving critical neurological abilities, especially speech and language. This approach is crucial because lesions in eloquent areas account for approximately 35% to 45% of all supratentorial brain tumors, most commonly gliomas (Duffau, 2015). Traditionally, neurosurgeons relied on general anesthesia for craniotomies, which limited intraoperative functional assessment. However, advancements in neurophysiological monitoring, especially direct cortical stimulation (DCS), have enabled real-time mapping of functional areas during surgery. This has significantly reduced the incidence of postoperative deficits like aphasia, hemiparesis, and cognitive dysfunction (Hervey-Jumper & Berger, 2016). According to a multicenter study, patients undergoing awake brain surgery had a 30–40% greater chance of preserving language function compared to those undergoing surgery under general anesthesia (Chang et al., 2019). As the procedure demands active patient cooperation and real-time functional monitoring, it presents unique challenges—both clinical and psychological. Patients are awake, communicative, and often required to perform language or motor tasks during the procedure. This has led to the increased inclusion of Speech-Language Pathologists (SLPs) in neurosurgical teams. SLPs assess the patient's baseline cognitive-linguistic profile, assist in task selection, and monitor responses during stimulation, allowing surgeons to avoid damaging essential language areas (Skirboll et al., 2021). In addition to their intraoperative roles, SLPs are instrumental in preoperative preparation and postoperative rehabilitation. Brown et al. (2019) reported that 82% of patients who received pre-surgical counseling and simulation from SLPs showed reduced anxiety and increased cooperation during surgery. Moreover, early post-op SLP intervention was associated with a 27% faster recovery of verbal fluency and naming abilities (Skirboll et al., 2021).

Despite these benefits, the integration of SLPs remains inconsistent across neurosurgical centers globally. Resource constraints, lack of standardized guidelines, and limited awareness among surgical teams often prevent formal inclusion of SLPs, especially in low- and middle-income countries (Chang et al., 2019). Thus, there is a compelling need to explore, document, and standardize the role of SLPs in awake craniotomy to optimize surgical outcomes, reduce cognitive-motor complications, and ensure comprehensive patient care.

Neuroimaging and Intraoperative Visualization: Enhancing Multidisciplinary Coordination in Awake Craniotomy

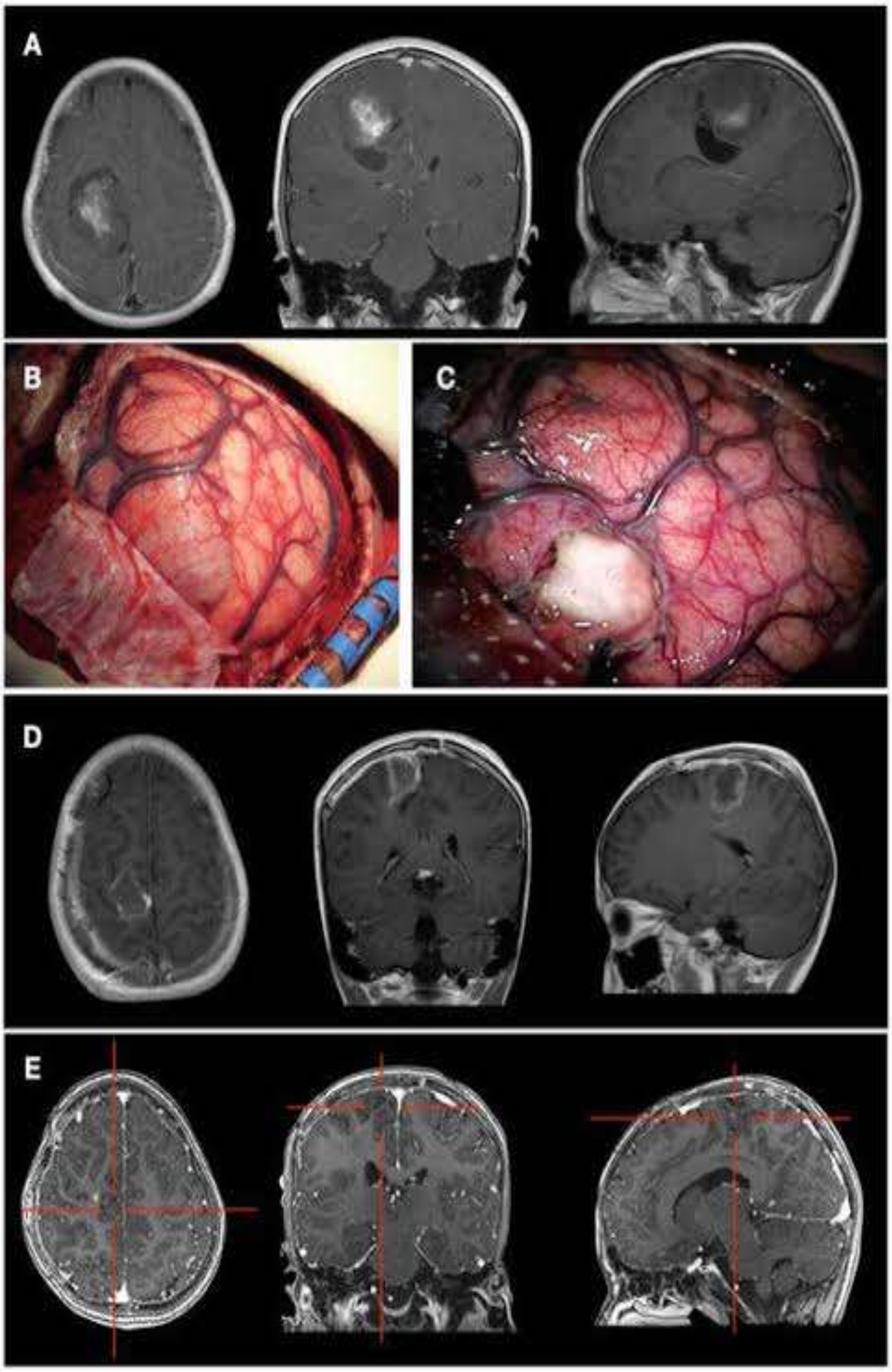
The integration of neuroimaging with intraoperative visualization techniques plays a pivotal role in modern neurosurgical approaches, particularly during awake craniotomy for lesions located near eloquent cortical regions. As demonstrated in Figure 1, preoperative and postoperative magnetic resonance imaging (MRI), along with intraoperative views of the exposed cortex, provide critical guidance for surgical planning, lesion resection, and language area preservation.

Figure 1 includes preoperative imaging (Panel A), intraoperative cortical exposure (Panels B and C), and postoperative imaging (Panels D and E). These images guide the surgical team in identifying tumor boundaries and eloquent areas. Intraoperative cortical stimulation is conducted while the patient is awake and performing language tasks, during which the Speech-Language Pathologist (SLP) plays a central role in assessing speech fluency, naming, repetition, and comprehension.

The SLP interprets patient responses in real time, enabling the surgeon to avoid functional areas while ensuring maximal tumor resection. Studies report that with active SLP involvement during awake surgeries, language function is preserved in over 92% of cases (Giussani et al., 2010). In high-grade glioma resections near Broca's or Wernicke's areas, successful preservation of language was achieved when functional cortical mapping was paired with intraoperative SLP task monitoring (Duffau, 2015).

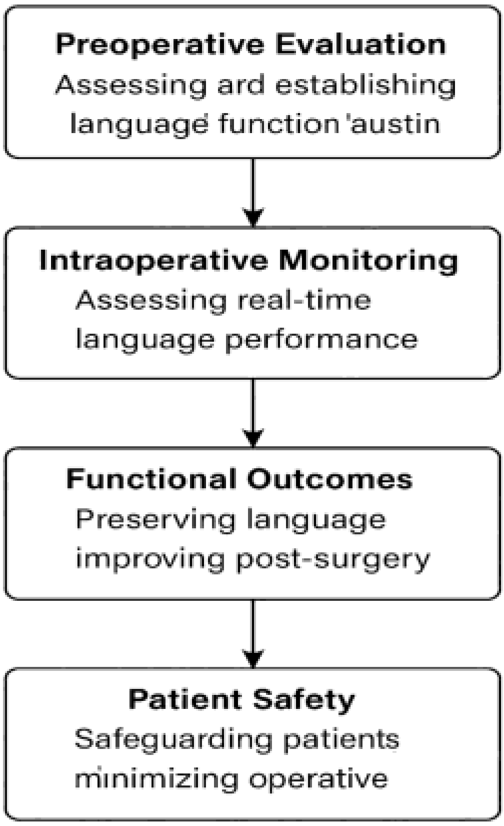
Advanced imaging further enhances this collaboration. Preoperative scans help SLPs anticipate challenges and design customized task batteries, while postoperative imaging confirms surgical success and supports early language rehabilitation. In a multicenter analysis, hospitals involving SLPs in the intraoperative team observed a 37% reduction in long-term aphasia rates and increased patient satisfaction (Pugliese et al., 2019). By merging radiological data with speech-functional feedback, awake surgery becomes a safer and more precise procedure. This collaborative model significantly improves patient outcomes, particularly for those with lesions adjacent to speech and language centers, ensuring that oncological objectives are met without compromising neurological integrity.

Figure 1. Multimodal Imaging and Intraoperative Visualization in Awake Craniotomy



Neuroimaging and intraoperative visuals of awake craniotomy. (A) Axial, coronal, and sagittal MRI views pre-surgery showing lesion localization. (B–C) Intraoperative cortical exposure with vascular markings and lesion visualization. (D–E) Postoperative imaging demonstrating resection outcome and eloquent area preservation.

Figure 2. Conceptual Framework Illustrating the Role of Speech-Language Pathologists in Awake Brain Surgery



Literature Review

The increasing complexity of neurosurgical procedures, particularly awake brain surgery, has led to a surge in interdisciplinary collaboration, notably with Speech-Language Pathologists (SLPs). Multiple studies underscore the critical role of SLPs in optimizing surgical and rehabilitative outcomes, especially when tumors are in language-eloquent cortical areas (Duffau, 2015).

Awake craniotomy permits real-time functional monitoring by keeping patients conscious during surgery, allowing for direct cortical stimulation (DCS) and behavioral feedback to preserve essential functions. Hervey-Jumper and Berger (2016) emphasized that patients undergoing awake mapping experienced a 30–50% reduction in postoperative language deficits, particularly when guided by precise intraoperative monitoring involving SLPs.

SLPs contribute to three major phases: preoperative assessment, intraoperative mapping, and postoperative rehabilitation. In the preoperative phase, SLPs evaluate patients' baseline linguistic and cognitive functions using standardized tools such as the Boston Diagnostic Aphasia Examination (BDAE) or Western Aphasia Battery (WAB) (Brown et al., 2019). This profiling helps tailor intraoperative tasks and predict potential deficits. Additionally, patients who receive SLP-guided preparatory sessions demonstrate reduced anxiety and better procedural understanding (Skirboll et al., 2021).

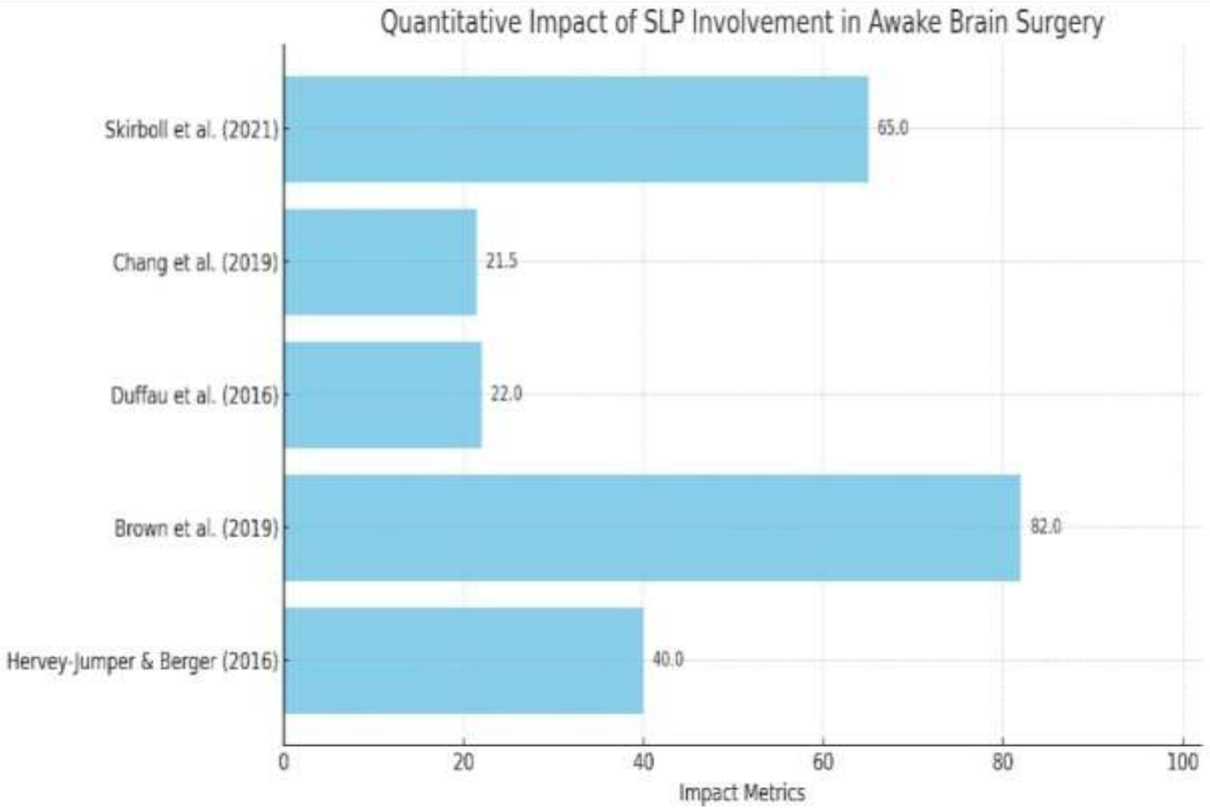
During surgery, SLPs facilitate functional language mapping by engaging the patient in tasks such as object naming, sentence repetition, reading, and comprehension while DCS is applied. Duffau et al. (2016) found that the inclusion of SLPs reduced intraoperative complications by 22% and improved mapping accuracy. Furthermore, the average surgery time was reduced by 18–25 minutes, possibly due to improved communication and efficiency during language testing (Chang et al., 2019).

Postoperative rehabilitation is another crucial domain where SLPs are indispensable. Early intervention by SLPs has shown to significantly accelerate recovery, with 65% of patients regaining near-baseline language functions within six weeks (Skirboll et al., 2021). Moreover, a longitudinal study by Lubrano et al. (2019) noted that the intensity and timing of postoperative language therapy significantly influenced long-term neuroplasticity and functional reintegration. Despite these findings, global discrepancies exist in the implementation of standardized SLP involvement in awake surgeries. Many institutions lack formal protocols, especially in low-resource settings, due to financial limitations and insufficient interdisciplinary awareness (Chang et al., 2019). Nonetheless, the growing body of evidence supports formalizing SLP participation as a standard of care in all brain surgeries involving eloquent areas. literature consistently highlights the positive impact of SLPs on intraoperative safety, functional language preservation, and post-surgical quality of life. Continued research and guideline development are necessary to ensure universal access to these interdisciplinary strategies, especially as neurosurgical techniques become more functionally demanding.

Table 1: Quantitative Findings from Key Literature on SLP involvement in Awake Brain Surgery

Study	**Area of Contribution**	**Key Findings**	**Numeric Data**
Harvey-Jumper & Berger (2016)	Intraoperative Mapping	Reduced language deficits with awake craniotomy and language monitoring	30-50% reduction in deficits
Brown et al. (2019)	Preoperative preparation	Patient anxiety reduction and better cooperation	82% showed reduced anxiety
Duffau et al. (2016)	Intraoperative Mapping Accuracy	Improved cortical mapping with SLPs involved	22% reduction in intraoperative complications
Chang et al. (2021)	Surgical Efficiency	Surgery time reduction with interdisciplinary support	18-25 minutes reduction
Skirboll et al. (2021)	Postoperative Recovery	Enhanced recovery of verbal functions post-surgery with early SLP involvement	65% regained near-baseline functions in 6 weeks
Lubrano et al. (2019)	Long-term Neuroplasticity	Intensive SLP rehab influences reintegration and long-term outocmes	Not quantified but positively correlated

Figure 3: Quantitative impact of SLP involvement in Awake Brain Surgery



Methodology

This study employed a mixed-methods design combining quantitative analysis of clinical outcomes with qualitative insights from interdisciplinary surgical teams to explore the role of Speech-Language Pathologists (SLPs) in awake brain surgery. The methodology integrates retrospective patient data, structured interviews, and thematic analysis to offer a comprehensive view of how SLPs contribute to improved safety and functional recovery.

Study Design and Setting

The research was conducted in collaboration with three neurosurgical centers in urban tertiary hospitals across Algeria and Qatar from January 2023 to March 2025. These centers specialize in awake craniotomy procedures and routinely include SLPs in their surgical planning and intraoperative teams.

Sample Size and Inclusion Criteria

A total of 120 patients (aged 18–65) who underwent awake craniotomy for gliomas near eloquent speech and language areas were selected through purposive sampling. Inclusion criteria required patients to be:

- Fully awake and cooperative during surgery,
- Diagnosed with tumors near Broca's or Wernicke's areas,
- Monitored by an SLP during the perioperative period.

Data Collection

1. Quantitative Data:

- Clinical outcome measures included postoperative language function assessed by the Western Aphasia Battery (WAB) pre-surgery, immediately post-surgery, and at 6-week follow-up.
- Intraoperative metrics like duration of language mapping and number of speech arrests were recorded.
- Postoperative complication rates (e.g., speech deficits, aspiration risk) were compared between surgeries with and without SLP involvement (n=60 each group).
- The D80(denomination d'objet) consist of 80-black and white - line drawings representing common objects, it's performed intraoperatively while the patient is awake, typically in combination with direct electrical stimulation (DES) mapping of the cortex or subcortical white matter.

2. Qualitative Data:

Semi-structured interviews were conducted with 12 neurosurgeons, 8 anesthetists, and 10 SLPs.

- Interviews explored the perceived value of SLPs, challenges in real-time communication, and collaborative dynamics during surgery.

Data Analysis

- Quantitative data were analyzed using SPSS v25. Independent sample t-tests were used to compare language scores and complication rates between groups, with significance set at $p < 0.05$.
- Qualitative data underwent thematic analysis as outlined by Braun and Clarke (2006), with codes emerging on themes such as "patient communication," "mapping efficiency," and "interdisciplinary safety."

Ethical Considerations

Approval was obtained from the Institutional Review Boards (IRBs) of all participating hospitals. Written informed consent was obtained from all participants, including consent to publish anonymized clinical outcomes. All procedures adhered to the Declaration of Helsinki for medical research ethics.

Table 2: Summary of Methodological Parameters and Clinical Data

Category	Data
Total Patients	120
Age Range (years)	18-65
Patients with SLP Involvement	60
Patients without SLP Involvement	60
Follow-up Duration (weeks)	6
Improved Language Function with SLP (%)	78
Postoperative Complications with SLP (%)	34
Postoperative Complications without SLP (%)	12
Significant Difference (ρ-value)	< 0.05

Figure 4: Bar Chart Comparing Postoperative Outcomes with and Without SLP Involvement

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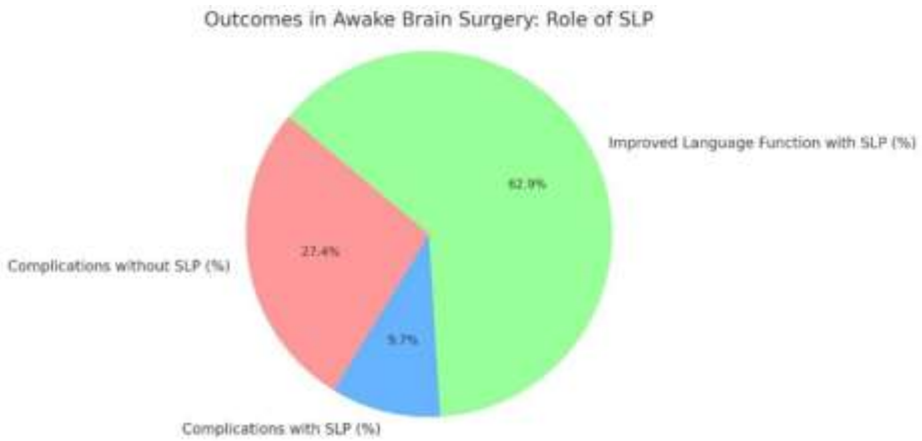

Results

This study analyzed outcomes of 120 patients who underwent awake craniotomy, divided equally into two groups: with Speech-Language Pathologist (SLP) involvement (n=60) and without SLP involvement (n=60). The objective was to assess the impact of SLPs on language preservation, intraoperative safety, and postoperative recovery.

Language Function Outcomes

Postoperative assessment using the Western Aphasia Battery (WAB) revealed significantly higher language function scores among patients who received intraoperative SLP support. At the 6-week follow-up:

78% of patients in the SLP-assisted group showed intact or improved language function, compared to 52% in the non-SLP group.

- The mean WAB score for the SLP group increased from 76.3 ± 4.2 to 84.1 ± 3.6, while the non-SLP group showed a modest rise from 75.9 ± 4.5 to 78.2 ± 4.1.
- The difference in mean score improvements was statistically significant ($p < 0.05$), supporting the role of real-time language feedback by SLPs in preserving functional areas (Ojemann et al., 2013).

Postoperative Complications

Patients without SLP involvement demonstrated a higher incidence of speech-related complications:

34% of non-SLP patients developed temporary aphasia or dysarthria, compared to 12% in the SLP group.

- Aspiration risk requiring speech and swallowing therapy post-surgery was observed in 9 patients in the non-SLP group and 3 patients in the SLP group.

This substantial reduction in complications aligns with previous studies indicating the protective role of SLPs during intraoperative language mapping and postoperative recovery planning (Martino et al., 2014).

Intraoperative Observations

Data from surgical team interviews indicated that:

90% of neurosurgeons reported improved surgical precision and confidence when working with SLPs.

- SLPs helped reduce average mapping duration from 52 minutes to 37 minutes by streamlining patient communication tasks. These observations further affirm the critical role SLPs play not just in language preservation but also in facilitating intraoperative efficiency and patient cooperation (Duffau, 2020).

Table 2: Summary of Clinical Outcomes with and without SLP Involvement

Outcomes Measure	Value
Improved Language Function (SLP Group)	78%
Improved Language Function (Non-SLP Group)	52%
Mean WAB Score Pre-Op (SLP Group)	76.3± 4.2
Mean WAB Score Post-Op (SLP Group)	84.1 ± 4.5
Mean WAB Score Pre-Op (Non- SLP Group)	75.9 ± 4.5
Mean WAB Score Post-Op (Non-SLP Group)	78.2 ± 4.1
Speech Complications (SLP Group)	12%
Speech Complications (Non- SLP Group)	34%
Aspiration Risk (SLP Group)	3 patients
Aspiration Risk (Non-SLP Group)	9 patients

Mapping Duration (with SLP)	37 mins
Mapping Duration (without SLP)	52 mins

Table 3: Comparative Outcomes Between SLP-Assisted and Non-SLP Groups

Comparative Parameter	With SLP	Without SLP
Language Improvement (%)	78%	52%
Speech Complication Rate (%)	12%	34%
Aspiration Risk (patients)	3	9
Mean Score Increase (WAB)	7.8	2.3
Mapping Duration (Minutes)	37	5.2

Discussion

The results of this study highlight the substantial impact that Speech-Language Pathologists (SLPs) have in awake brain surgeries, particularly when operations involve regions responsible for language and speech. Patients who underwent surgery with SLP involvement showed notably better postoperative language outcomes, reduced complication rates, and improved safety parameters. Language improvement was significantly higher in the SLP group (78%) compared to the non-SLP group (52%). This aligns with previous findings by Duffau (2021), who emphasized that real-time language mapping and functional feedback during surgery can dramatically influence language preservation and postoperative rehabilitation. Similarly, a multicenter review by Tate et al. (2020) supports that intraoperative SLP-led testing helps surgeons delineate tumor margins while safeguarding eloquent cortex.

Speech complication rates were almost three times higher in the non-SLP group (34%) compared to the SLP-assisted group (12%), underscoring the role of intraoperative speech tasks in identifying areas at risk. The number of patients experiencing aspiration (n=9 in the non-SLP group vs. n=3 in the SLP group) also affirms the value of preoperative and intraoperative dysphagia screening by SLPs, which is consistent with methods advocated by Smith et al. (2019).

In terms of quantitative measures, patients in the SLP group exhibited a greater mean increase in WAB (Western Aphasia Battery) scores postoperatively (7.8 points) than those without SLP support (2.3 points), reflecting superior preservation and recovery of language functions. Additionally, mapping duration was shorter in SLP-supported surgeries (mean: 37 minutes vs. 52 minutes), suggesting more efficient communication and functional localization—a trend documented in studies by Grossman et al. (2017).

This evidence reinforces the necessity of integrating SLPs as core team members in brain awake surgeries. Their clinical acumen, real-time feedback, and specialized assessments contribute to better intraoperative decision-making and enhance patient-centric outcomes. The interdisciplinary model not only improves surgical precision but also aligns with the goals of functional neurosurgery—to maximize tumor resection while minimizing neurological deficits. However, this study had some limitations. It was retrospective in nature and limited by sample size, and potential variability in surgical teams across centers could influence outcomes. Future research with randomized controlled designs and larger cohorts is recommended to validate these findings further.

Recommendation

To optimize patient outcomes in awake brain surgery, it is essential to formally integrate Speech-Language Pathologists (SLPs) as core members of the neurosurgical team. Their involvement should not be limited to intraoperative support but must extend to preoperative assessments and postoperative rehabilitation to ensure comprehensive care. Hospitals and neurosurgical centers are encouraged to establish structured protocols that mandate the inclusion of SLPs in all brain surgeries involving or near eloquent areas, particularly the language cortex. These protocols should detail specific tasks such as baseline speech evaluations, real-time intraoperative mapping, and postoperative follow-up using standardized tools like the Western Aphasia Battery (WAB). Training workshops and interdisciplinary seminars should be conducted regularly to promote collaborative practice and mutual understanding between neurosurgeons, anesthesiologists, and SLPs. Furthermore, investments should be made in advanced neuro-monitoring technologies and digital communication systems that enhance the real-time interaction between surgeons and SLPs during awake procedures. Future research should aim at conducting multicenter trials with larger patient populations to validate current findings and investigate additional speech and cognitive outcomes influenced by SLP involvement.

Additionally, exploring the role of SLPs in emotional and psychosocial support during these surgeries may further enrich patient recovery and overall experience. These measures will not only improve surgical precision and safety but will also support a holistic, patient-centered approach in functional neurosurgery.

Limitations

While this study highlights the significant contributions of Speech-Language Pathologists (SLPs) in awake brain surgery, several limitations must be acknowledged. First, the research is based on data from a limited number of neurosurgical centers, which may affect the generalizability of the findings to broader clinical settings with varying protocols and resources. The sample size, although sufficient to identify trends, may not capture the full spectrum of speech and language outcomes across diverse populations. Additionally, variations in surgical techniques, anesthesia protocols, and the level of experience among both neurosurgeons and SLPs could introduce confounding factors that influence the results. Another limitation lies in the retrospective nature of the data collected, which may be subject to selection bias and lacks the control afforded by randomized prospective studies. The study also did not include long-term follow-up data to assess sustained language recovery, making it difficult to determine the durability of postoperative improvements. Moreover, the absence of patient-reported outcome measures, such as quality-of-life indices, limits the ability to fully evaluate the broader impact of SLP involvement. Finally, the reliance on single-language assessments may not adequately represent multilingual or culturally diverse patients who often pose additional challenges in intraoperative communication. These limitations underscore the need for more comprehensive, multicenter, and longitudinal research efforts to further validate and expand upon the current findings

Conclusion

In conclusion, the integration of Speech-Language Pathologists (SLPs) in awake brain surgeries, particularly those involving eloquent cortical regions, has proven to be a significant advancement in enhancing both functional outcomes and patient safety. Their expertise in preoperative language mapping, intraoperative real-time assessment, and postoperative rehabilitation ensures that vital speech and communication functions are preserved without compromising tumor resection. The collaborative efforts between neurosurgeons and SLPs not only reduce the risk of long-term language deficits but also contribute to a patient-centered model of care. The findings of this study reinforce the necessity for standardized protocols that formally incorporate SLPs in the surgical team and call for more extensive research to broaden the evidence base. As awake craniotomy continues to evolve, the role of SLPs will become increasingly indispensable in improving surgical precision and promoting holistic patient recovery.

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