Presence of a translator in the operating theater for awake mapping in foreign patients with low-grade glioma: a surgical experience based on 18 different native languages

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OBJECTIVE Intraoperative brain mapping with neurocognitive monitoring during awake surgery is currently the standard pattern of care for patients with diffuse low-grade glioma (DLGG), allowing a maximization of the extent of resection (EOR) while preserving quality of life. This study evaluated the feasibility of DLGG resections performed with intraoperative cognitive monitoring via the assistance of a translator for patients speaking foreign languages, and compared the surgical functional and oncological outcomes according to the possibility of direct communication with the surgical team.

METHODS Foreign patients who underwent awake surgery with intraoperative electrical mapping with the assistance of a translator for the resection of a DLGG in the authors' institution between January 2010 and December 2020 were included. Patients whose native language included one of the three languages spoken by the surgical team (i.e., French, English, or Spanish) were excluded. The patients were classified into two groups. Group 1 was composed of patients able to communicate in at least one of these three languages in addition to their own native language. Group 2 was composed of patients who spoke none of these languages, and therefore were unable to communicate directly with the operating staff. The primary outcome was the patients' ability to return to work 3 months after surgery.

RESULTS Eighty-four patients were included, of whom 63 were classified in group 1 and 21 in group 2. Eighteen different native languages were tested in the operating theater. Awake mapping was successful, with elicitation of transitory disturbances in all patients. There was no significant difference in the 3-month return-to-work status between the two groups (95% in group 1 [n = 58/61] vs 88% in group 2 [n = 15/17]; p = 0.298). Similarly, no significant difference between the two groups was found regarding the intraoperative tasks performed, the mean duration of the surgery, and the rate of permanent postoperative deficit. A significantly greater EOR was observed in group 1 patients in comparison to group 2 patients (90.4% ± 10.6% vs 87.7% ± 6.1%; p = 0.029).

CONCLUSIONS Real-time translation by an interpreter during awake resection of glioma is feasible and safe in foreign patients. Nonetheless, when no direct verbal communication is possible between the surgical team and the patient, the EOR is less.

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KEYWORDS awake surgery; intraoperative mapping; foreign patients; language translation; low-grade glioma; return to work; oncology

OVER the past decade, a large amount of surgical studies have shown the important role of extensive early resection in patients with diffuse low-grade glioma (DLGG).^{1–5} Intraoperative electrical stimulation mapping is currently the gold standard for direct detection of neural structures essential for brain functions.^{6–8}

By permitting tumor resection according to the functional boundaries, intraoperative brain mapping with neurocognitive monitoring during awake surgery increases the extent of resection (EOR) and then the overall survival, but also preserves the patient's quality of life and the cumulative time with an active life.^{7,9,10} Indeed, direct cortical and

ABBREVIATIONS ACTFL = American Council on the Teaching of Foreign Languages; DES = direct electrostimulation; DLGG = diffuse low-grade glioma; DO 80 = picture-naming task; EOR = extent of resection; PPTT = Pyramids and Palm Trees test.

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subcortical brain stimulation is essential for monitoring and preserving language (speech, naming, and reading) and cognitive abilities (motor execution and control, visuospatial awareness, semantics, executive functions, and emotion including empathy).^{11–13}

In foreign patients, when no direct verbal communication is possible between the surgical team and the patient, intraoperative cognitive evaluation can be complex, even in the presence of a translator. Difficulties in communicating efficiently with the patient during surgery due to the language barrier may indeed disturb the real-time evaluation and interpretation of stimulation-induced possible transient disorders, which then might increase the risk of lasting deficits or limit the EOR. The real-time estimation of the so-called onco-functional balance may thus be distorted, making precise tumor resection difficult according to cortico-subcortical functional boundaries.

Numerous studies have attempted to determine the language pathways in multilingual patients,^{14–17} and the functional anatomy underlying language switching.^{18–21} However, to date, very few series have described the surgical management in foreign patients with glioma undergoing awake surgery,^{22,23} and there are no existing data about the outcome of these patients whose native language differs from the surgical team's language. The aim of our work was to evaluate the feasibility of DLGG resections in awake foreign patients with intraoperative real-time cognitive mapping and monitoring via the assistance of a translator, and to compare the surgical functional and oncological outcomes according to the possibility or not of direct communication with the surgical team.

Methods

Patient Population

Every consecutive patient of foreign nationality who underwent awake surgery for DLGG resection with intraoperative electrical mapping with a translator in our neurosurgery department between January 2010 and December 2020 was included. Patients whose native language included one of the three languages spoken by the surgical team (i.e., French, English, or Spanish) were excluded. The remaining patients were classified into two groups, according to the possibility to communicate directly with our team in a foreign language, at an intermediate level at least. Group 1 was composed of patients able to communicate in French, English, or Spanish, in addition to their own native language. Group 2 was composed of patients who spoke none of these languages, and therefore were unable to communicate directly with the operating staff.

According to the American Council on the Teaching of Foreign Languages (ACTFL) guidelines,²⁴ intermediate-level speakers are able to talk about familiar topics related to their daily life, express personal meaning, ask simple questions, and handle a straightforward survival situation.

All of the surgical procedures were performed by the same neurosurgeon (H.D.) following the standard management of patients with a lower-grade glial tumor in our center. Informed consent for this surgical procedure was obtained from all patients, and all of them agreed to the retrospective analysis of their clinical data, in accordance

with the ethical standards of the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Outcomes

The primary outcome was the patients' ability to return to work 3 months after surgery.

Secondary endpoints were the EOR on the 3-month postoperative MRI, the number of patients lost to follow-up 3 months postoperatively, and the presence of permanent neurological deficit after surgery. Neurological deficits that persisted 1 year after surgery were regarded as permanent. The EOR was evaluated on the 3-month postoperative MRI using the classification reported by Berger et al.²⁵

Data Collection

Information concerning the following variables was recorded prospectively for all patients: demographics (sex, age at diagnosis, occupation); handedness; clinical manifestations (neurological deficit, preoperative seizure, language evaluation); tumor characteristics (laterality, location, preoperative volume); possible previous surgery or biopsy; intraoperative mapping data (tasks performed, type of disturbances induced by direct electrostimulation [DES], duration of surgery); EOR; histopathological results; possible complications; neurological outcome; return to work and its delay after surgery; and possible second surgery and its delay.

Patients' occupations were classified using the 2008 International Standard Classification of Occupations (ISCO-08), organizing all jobs into a defined set of groups (from 0 to 9) according to the tasks and duties undertaken in the job.²⁶ Patients' native language, their eventual secondary language(s), the country of residence, and the number of languages spoken and tested intraoperatively were recorded.

Patients' Perioperative Evaluation

Prior to surgery, a standard neuropsychological assessment was performed at the patient's home abroad when available in his/her country.

In the perioperative period, each patient was assessed in our institution by the same senior neuropsychologists (G.H. or A.L.L.) and speech-language therapist (S.M.G.) before, during, and immediately (3–5 days) after the surgery. An institutional or professional interpreter was present each time. An explanation was previously given to the interpreter about the types of language disorders, allowing him/her to detect semantic and phonological paraphasia, dysarthria/anarthria, perseveration, and anomia. For each test, the interpreter was instructed to specify aloud whether the patient's response was correct or not, and to inform about the type of disorder. This allowed the assessor to detect the different errors online. Similarly, the translator had to inform the evaluator of any feedback or complaint provided by the patient, including visual or somatosensory subjective information.

Language assessment included an evaluation of the spontaneous speech, a semantic fluency task (consisting

of producing the highest number of words belonging to a given semantic category), and a timed naming task (DO 80) consisting of 80 black-and-white pictures.²⁷ In multilingual patients, this last task was also performed in their second language(s), if considered essential by the patient. The battery of tests usually administered preoperatively and immediately after the surgery²⁸ could be adapted to cultural constraints (e.g., for the naming task, in several languages the word “seat” is interchangeably used to name a chair, an armchair, a stool, or a bench). A restricted set of items with 100% success was tailored for each patient and further used intraoperatively. Language and semantic assessments were adapted as far as possible to the patient’s native language, as well as his/her comprehension of the Latin alphabet, his/her level of education, the presence of a preexisting cognitive or attentional impairment, and the tumor location. Considering these elements and the patient’s complaint, additional cognitive tests could be proposed during perioperative management.

Intraoperative Monitoring and Electrostimulation Mapping Protocol

The complete description of the surgical approach used in our institution in patients undergoing craniotomy under local anesthesia with cortical and subcortical electrostimulation functional mapping has been exhaustively described in previous studies.^{11,29,30} The interpreter was present in the operating theater during the mapping and resection phase in both groups. He/she translated the patient’s responses in his/her native language to the neuropsychologist/speech-language therapist in real time. As for the assessor and the patient, the translator was not aware of when and where stimulations were delivered.

In contrast to our regular procedure, intraoperative monitoring was adapted to the language barrier, often resulting in a reduced number of tests performed. For language mapping, at least two tasks were systematically used. Speech articulation and movement were assessed with a simple counting task in the patient’s native language (from 1 to 10), associated with contralateral repetitive arm movement (dual tasking). Spoken language was assessed with the DO 80 picture-naming task^{27,31} in the patient’s native language with simultaneous translation by the translator. Different languages could be tested alternatively in multilingual patients if planned during the preoperative meeting, in addition to the patient’s native language, which was systematically tested.

Other intraoperative monitoring tasks could be used according to the tumor location, the language barrier, the preoperative evaluation, and the patient’s needs. The “Pyramids and Palm Trees” test (PPTT) was thus used for nonverbal semantic cognition,^{32,33} the line bisection task for spatial cognition,³⁴ the modified picture-naming task with 2 pictures placed diagonally on the screen for visual field monitoring,³⁵ a word-reading task for reading assessment,³⁶ and the “Reading the Mind in the Eyes” test³⁷ for mentalizing assessment.^{38–40}

Postoperative Assessment and Surgical Outcome

Immediate postoperative neuropsychological and

speech therapist assessment was systematically preplanned at the patients’ home abroad before their admission to hospital. After surgery, patients were urged to receive an intensive personalized 3-month cognitive rehabilitation in their country of residence, based on this postoperative evaluation. The postoperative neurological status and the return-to-work status were assessed by the surgeon at the 3-month and 1-year postoperative appointments, even for the patients living abroad. Finally, follow-up MRI was performed in all cases immediately after surgery and 3 months postoperatively.

Statistical Analysis

All statistical analyses were conducted using GraphPad Prism 7.0 software (GraphPad Software, Inc.). Categorical variables are presented as numbers and percentages, and continuous variables are presented as the median and interquartile range or the mean $\pm$ SD. The significance of baseline differences was determined by the Pearson’s chi-square test or the Fisher’s exact test for categorical values. The Mann-Whitney U-test was used to compare continuous variables. A 2-sided p value ≤ 0.05 was considered to indicate statistical significance.

Results

Patient Population

A total of 84 consecutive foreign patients underwent awake craniotomy for DLGG in our institution. The series consisted of 36 women (43%) and 48 men (57%), with a mean age of 38.7 ± 9.7 years. Sixty-three patients (75%) were able to communicate directly with our surgical staff in English, Spanish, or French, in addition to their native language (group 1), whereas 21 patients (25%) did not speak or understand any of these 3 languages (group 2). A flowchart illustrating the selection of our patients is shown in Fig. 1.

The lesion was located in the left hemisphere in 56 cases (67%) and in the right hemisphere in 28 cases (33%). Eighteen patients (21%) had already been operated on in another institution, 50% ($n = 9$) of whom were biopsied. The mean preoperative tumor volume was 64.3 ± 38.6 cm³. Clinical data and tumor characteristics are summarized in Table 1. The lesion volume was higher in group 2 in comparison with group 1. Moreover, paralimbic location was more frequent in group 2, whereas temporal location was more frequent in group 1. There were no other significant differences between both groups among all the demographic, clinical, radiological, and histopathological variables considered ($p > 0.1$).

Eighteen different native languages were identified in patients originating from 26 countries and living in 27 different countries at the time of the surgery. Among them, 61% ($n = 51$) spoke several languages fluently, of whom 90% ($n = 46$) were bilingual and 10% ($n = 5$) were trilingual. Native and second language information is shown in Tables 2 and 3.

Intraoperative Mapping

The interpreter was present each time with the speech therapist or neuropsychologist. Awake mapping was suc-

FIG. 1. Flow diagram detailing how patients were selected for our study. *According to ACTFL guidelines.

cessful in all cases, with induction of transitory disturbances in the native language of all patients by using electrostimulation. No language or communication difficulties prevented cognitive intraoperative monitoring according to the preoperatively established strategy. During surgery, dual tasking and the naming task were performed by every patient. A semantic association task (PPTT) was also performed in 40% (n = 25) of group 1 patients, as well as in 24% (n = 5) of group 2 patients (p = 0.293). Additional intraoperative tasks (mentalizing, line bisection, visual field, or reading task) were performed in 33% (n = 21) of group 1 patients and in 14% (n = 3) of group 2 patients (p = 0.161). Different languages were tested during surgery in 44% (n = 28) of group 1 patients, whereas only native language was tested for group 2 patients. There was a slight difference regarding the mean duration of the surgery between the two groups (246.8 ± 33.6 minutes for group 1 patients vs 268.5 ± 51 minutes for group 2 patients; p = 0.058). Surgical monitoring data are summarized in Table 4.

Return to Work

Three patients were unemployed at the time of the surgery, and return-to-work data of 3 other patients were not available during follow-up. Among the remaining 78 previously employed patients, 94% were able to work at 3 months postoperatively. There was no significant difference in the 3-month return-to-work status between the two groups (95% in group 1 [n = 58/61] vs 88% in group 2 [n = 15/17]; p = 0.298). The reasons for not returning to work were a postoperative infection in 1 group 1 patient, the introduction of intravenous chemotherapy in her native country in 1 group 2 patient, and the prolongation of the rehabilitation period for the 3 other patients. None of

them had refractory epileptic seizures in the postoperative period.

Surgical Outcome

According to the standard neurological examination, 52% (n = 33) of patients in group 1 experienced expected immediate postoperative worsening: 23 had language impairments, 10 had sensorimotor deficit, and 5 had articulation disorders. One year after surgery, only 2 patients still had a mild permanent deficit: 1 patient with left parietal glioma showed a proprioceptive deficit of the right lower limb, and 1 patient with right paralimbic glioma experienced some dysesthesias. In group 2, 76% (n = 16) of patients presented with expected postoperative worsening: 12 had language disorders, and 4 had sensorimotor deficits. Only one of them, who underwent surgery for left parietal glioma, still had a mild permanent deficit at 1 year after surgery, with dysesthesias of the right hand.

Of the 81 patients with 1-year follow-up, 96% (n = 78) were free of neurological deficit 1 year after the surgery, and none of them presented a severe permanent deficit. There was no significant difference between the two groups regarding the existence of a permanent deficit after surgery (3% [n = 2/61] in group 1 vs 5% [n = 1/20] in group 2; p = 1).

The mean EOR of our cohort was 90% ± 10.0%. The mean EOR of group 1 patients was significantly higher than that of group 2 patients (91% ± 10.9% vs 87.4% ± 6.4%; p = 0.012). Total, subtotal, and partial resection were achieved in 25% (n = 16), 59% (n = 37), and 16% (n = 10) of group 1 patients, respectively, and in 10% (n = 2), 57% (n = 12), and 33% (n = 7) of group 2 patients (p = 0.121; Fig. 2).

TABLE 1. Clinical data and tumor characteristics in 84 patients with DLGG

Characteristic	Total Population, n = 84 (%)	Groups		p Value
		Group 1, n = 63 (%)	Group 2, n = 21 (%)	
Demographics				
Age in yrs, mean ± SD	38.7 ± 9.7	38.6 ± 10.3	39 ± 7.8	NS
Sex, female	36 (42.9)	30 (47.6)	6 (28.6)	NS
Handedness, rt-handed	80 (95.2)	59 (93.7)	21 (100)	NS
Occupations according to ISCO-08*				
Group 0—Armed Forces occupations	1 (1.2)	1 (1.6)	0	NS
Group 1—managers	7 (8.3)	6 (9.5)	1 (4.8)	NS
Group 2—professionals	50 (59.5)	40 (63.5)	10 (47.6)	NS
Group 3—technicians & associate professionals	3 (3.6)	1 (1.6)	2 (9.5)	NS
Group 4—clerical support workers	9 (10.7)	7 (11.1)	2 (9.5)	NS
Group 5—service & sales workers	5 (6)	4 (6.3)	1 (4.8)	NS
Group 7—skilled agricultural, forestry, & fishery workers	3 (3.6)	2 (3.2)	1 (4.8)	NS
Group 8—plant & machine operators & assemblers	1 (1.2)	0	1 (4.8)	NS
Unemployed/student	5 (6)	2 (3.2)	3 (14.3)	NS
Clinical features				
First symptoms				
Epilepsy	69 (82.1)	50 (79.4)	19 (90.5)	NS
Phasic disorders	17 (20.2)	15 (23.8)	2 (9.5)	NS
Incidentaloma	10 (11.9)	9 (14.3)	1 (4.8)	NS
Preop DO 80 naming task				
Median score/80, IQR	79, 75.5–80	79, 75.8–80	79.5, 75.3–80	NS
First surgery in another center	18 (21.4)	14 (22.2)	4 (19.1)	NS
Histopathology, WHO 2016				
Diffuse astrocytoma, <i>IDHm</i>	31 (36.9)	25 (39.7)	6 (28.6)	NS
Diffuse astrocytoma, <i>IDHwt</i>	3 (3.6)	3 (4.8)	0	NS
Oligodendroglioma, <i>IDHm</i> 1p/19qcode1	35 (41.7)	23 (36.5)	12 (57.1)	NS
Oligoastrocytoma, NOS	6 (7.1)	6 (9.5)	0	NS
Oligodendroglioma, NOS	9 (10.7)	6 (9.5)	3 (14.3)	NS

IDHm = *IDH* mutant; *IDHwt* = *IDH* wild type; ISCO-08 = 2008 International Standard Classification of Occupations; NOS = not otherwise specified; NS = not significant ($p > 0.1$); 1p/19qcodelet = 1p/19q codeleted.

* Population counts for group 6 and group 9 are zero, so they are not listed.

No significant EOR difference was observed between the 31 patients with diffuse astrocytoma *IDH* mutant and the 35 patients with oligodendroglioma *IDH* mutant 1p/19q codeleted ($p = 0.582$).

Postoperative Course and Complications

The mean follow-up after surgery was 42.3 ± 33.5 months. There were no deaths in the series. One patient (1%) presented with infectious complication in the year following surgery. Seven patients (8%) underwent a second resection in our center, after a mean delay of 51 ± 18 months, which was 8% ($n = 5$) in group 1 and 10% ($n = 2$) in group 2 ($p = 1$). Two patients (2%) did not show up for the 3-month postoperative appointment (1 patient [2%] in group 1 and 1 patient [5%] in group 2; $p = 0.440$).

Discussion

This original series reports the successful achievement

of DLGG resection under awake surgery according to the functional boundaries in 84 foreign patients speaking 18 different native languages. Return to work 3 months after surgery was possible for 94% of patients, with no significant difference between the two groups. To the best of our knowledge, this is the first demonstration in a large surgical cohort of the feasibility of using intraoperative monitoring in foreign patients despite a language barrier, thanks to real-time translation by an interpreter in the operating theater.

Feasibility of Intraoperative Monitoring

There was no significant difference between the two groups on the most commonly performed intraoperative tasks (namely DO 80 naming task and dual tasking). PPTT and other behavioral tasks (mentalizing, line bisection, visual field, or reading task) were conducted in both groups, even if more frequently performed when direct communication was possible (40% and 33% in group 1 vs

TABLE 2. Data on 18 different native languages in 84 patients with DLGG

Native Language	Total Population, n = 84	Groups	
		Group 1, n = 63	Group 2, n = 21
Albanian	1	0	1
Arabic	18	14	4
Bulgarian	1	1	0
Creole	1	1	0
Danish	1	1	0
Dutch	2	2	0
German	6	6	0
Greek	12	10	2
Italian	5	3	2
Norwegian	1	0	1
Polish	1	0	1
Portuguese	20	15	5
Romanian	6	3	3
Russian	3	1	2
Serbian	1	1	0
Slovenian	1	1	0
Swedish	2	2	0
Turkish	2	2	0

24% and 14% in group 2, respectively; $p = 0.161$). Duration of surgery was slightly longer for group 2 patients (247 vs 269 minutes; $p = 0.058$), albeit not significant and partly explained by a larger tumor volume in group 2 patients. Intensive preparation of foreign patients during the preoperative period probably contributed to these favorable monitoring results. Patients of this series were evaluated before surgery by the same neuropsychologist/speech-language therapist with the same interpreter as during surgery, which reinforces the connection between the patient, the translator, and the surgical staff. Thus, with a translator trained to recognize the possible functional signs induced by brain electrostimulation, to transmit subjective symptoms and complaints of the patient, and to manage him/her in these special conditions, there were no additional difficulties of performing awake surgery, even with a complete language barrier.

In the literature, the feasibility of this kind of surgery has already been suggested by Aubrun et al.,²³ who recent-

TABLE 3. Secondary language data in 84 patients with DLGG

Secondary Language	Total Population, n = 84 (%)
1 secondary current language	46 (54.8)
English	25 (29.8)
French	20 (23.8)
Swedish	1 (1.2)
2 secondary current languages	5 (6)
French & English	4 (4.8)
Romanian & French	1 (1.2)

TABLE 4. Intraoperative monitoring in 84 patients with DLGG

Variable	Groups	
	Group 1, n = 63 (%)	Group 2, n = 21 (%)
Intraop task		
Dual tasking	63 (100)	21 (100)
DO 80 naming task	63 (100)	21 (100)
PPTT	25 (39.7)	5 (23.8)
Other tasks	21 (33.3)	3 (14.3)
Mentalizing	10 (15.9)	2 (9.5)
Line bisection	9 (14.3)	1 (4.8)
Visual field	2 (3.2)	0
Reading task	2 (3.2)	0
Disturbance induced by DES		
Movement arrest/acceleration	59 (93.7)	18 (85.7)
Anarthria	52 (82.5)	18 (85.7)
Involuntary motor contraction	41 (65.1)	14 (66.7)
Semantic paraphasia	35 (55.6)	15 (71.4)
Anomia	33 (52.4)	14 (66.7)
Perseveration	26 (41.3)	10 (47.6)
Phonological paraphasia	9 (14.3)	8 (38.1)
Dyesthesia	12 (19.1)	4 (19.1)
Semantic association	14 (22.2)	1 (4.8)
Mentalizing error	8 (12.7)	1 (4.8)
Line bisection error	7 (11.1)	0
Language switching	6 (9.5)	0
Alexia	2 (3.2)	0
Visual field	2 (3.2)	0
No. of languages tested		
2	26 (41.3)	0
3	2 (3.2)	0
Duration of surgery in mins, mean $\pm$ SD	246.8 $\pm$ 33.6	268.5 $\pm$ 51

ly published a case series of 5 migrant patients speaking 4 different native languages, but unable to speak French or English. All of them underwent awake surgery with successful intraoperative mapping, with a dedicated team and the involvement of an interpreter.²³ In this study, tasks were selected according to the tumor location and included repetitive movement of the contralateral upper limb, picture naming, and PPTT. Contrary to our series, however, there were no additional tasks set up in the operating theater. The main limitation of this study was the impossibility of organizing postoperative speech and cognitive rehabilitation, because the investigators could not find speech therapists speaking the patients' language in their city of residence in France.

Functional Outcome

The absence of direct verbal communication between the patient and the surgical team was not associated with a delayed return to work, because no significant differences were found between the two groups at 3 months postoperatively (95% in group 1 vs 88% in group 2; $p = 0.298$).

FIG. 2. Comparison of EOR in both groups. **Left:** Boxplot of the EOR for the group 1 and the group 2 patients with median, minimum, and maximum whiskers and quartile boxes. There was a statistically significant difference in the EOR between both groups ($p = 0.012$). **Right:** Bar chart of total, subtotal, and partial resection for group 1 and group 2 patients. There was no significant difference between groups ($p = 0.121$).

Only 3 patients (4%) reported a minor somatosensory permanent deficit 1 year after the surgery, and the risk of permanent deficit was not increased in group 2 patients ($p = 1$). These results are comparable to those of historical cohorts in which intraoperative monitoring was used in the absence of a language barrier: the return-to-work rate in a recent cohort of 68 incidentalomas in French-speaking patients was 91% within 12 months, with a mean time of 6.8 months.⁴¹ Similarly, no additional risk was observed in our cohort of foreign patients in comparison to previous studies: the risk of permanent deficits is nowadays less than 4%.^{4,8,41,42}

We highlight here the safety of awake surgery assisted with a translator in foreign patients, with a particularly high rate of resumption of the patients' professional activities and no additional risk of permanent neurological deficit in both groups. These favorable outcomes are associated with intensive and early rehabilitation management based on the data obtained in the immediate postoperative neuropsychological assessment. This specific rehabilitation strategy is recommended to facilitate the patient's recovery or even to improve their cognitive status compared to the preoperative scores.⁴³ In practice, the rehabilitation period can be a financial problem in some countries.⁴⁴ In spite of these differences in financial support, we ensured that personalized rehabilitation was systematically carried out by the patient: emphasizing its role right from the preoperative consultation, we systematically asked patients to preplan the rehabilitation in their country of residence prior to their admission to hospital. A selection bias may contribute to these good functional results: all of the foreign patients included were highly motivated to solicit us and to accept the difficulties involved in the implementation of a surgery in a different country. Consequently, working conditions in the operating theater and during the 3-month postoperative rehabilitation were particularly favorable.

In the literature, 1 preliminary study assessed the functional results of awake surgery in foreign patients: Kelm et al.'s cohort compared the functional outcomes of a population of 14 patients who were speakers of foreign languages

to 61 German patients.²² There were no significant differences between the groups in their pre-, intra-, and postoperative evaluation in terms of language evaluation. Consistent with our results, the risk of permanent deficit was not increased in patients with a language barrier: new surgery-related permanent deficits occurred in 3 cases (6%) of the German-speaking group and in 2 cases (14%) of the non-German-speaking group ($p = 0.48$).

Oncological Outcome

A mean EOR of 90% was achieved in our cohort. However, the absence of direct communication with the patient during surgery in our series was associated with an increased postoperative residual volume, because the EOR was higher in group 1 than in group 2 ($91\% \pm 10.9\%$ vs $87.4\% \pm 6.4\%$; $p = 0.012$). Even though we did not observe any communication difficulties during surgery, interaction between the surgeon, the speech therapist, and group 2 patients was only indirect via a translator. We hypothesize that this total lack of direct communication in group 2, and thus the increased risk of underestimation of DES-induced impairments, resulted in greater surgical caution with smaller resection cavities, in order to preserve quality of life. On the other hand, a significantly more frequent paralimbic localization and a higher tumoral volume were responsible for more surgical complexity in group 2 patients and may also explain the lower EOR. This additional surgical difficulty also justifies why these patients could not be operated on in their respective countries and came to a specialist center abroad, despite the difficulties of communication generated. Thus, the slightly lower EORs in these patients are balanced by the difficulty in being treated in tertiary centers dedicated to DLGG management in their respective countries. Besides, there is still the possibility of a reoperation in the future, as was achieved for 10% of group 2 patients, to allow a better resection. Indeed, it has been previously shown that a second operation, whenever possible, can optimize the oncological result with an earlier functional recovery.⁴⁵

Interestingly, a smaller EOR in the presence of a language barrier was also observed in Kelm et al.'s cohort:²² residual tumor tissue was found on postoperative MRI in 38% of German-speaking patients and in 71% of non-German-speaking patients ($p = 0.04$). However, the evaluation of foreign patients was not performed by a neuropsychologist or speech-language therapist during surgery in the second group, which also contributed to the decrease in EOR in this group.

Limitations

Data from the preoperative and 3-month postoperative cognitive assessment were incomplete in our series. The standard preoperative assessment usually performed in our center was often reduced due to the language barrier. For example, the phonological fluency test (saying the largest possible number of words beginning with the same letter in 2 minutes) was not performed in patients who do not use the Latin alphabet. Similarly, we had insufficient data on the postoperative neurocognitive assessment of patients. Indeed, neuropsychological care and evaluation was dispensed most of the time in the patients' home country,

and longitudinal results of cognitive and language assessments were often not available. Consequently, we chose the variable “return to work” to assess the functional results of our cohort. Indeed, the first wish of foreign patients coming to our department for surgery was the optimization of the onco-functional balance by increasing the EOR while resuming an active life, especially concerning the professional aspects. This explains the choice of the return-to-work variable as the first endpoint of our study.

The size of our two groups differed, and the significance of the resulting comparisons should be considered with caution. However, we reported a small but significant difference in terms of EOR between the two groups, highlighting the impact that direct communication between the patient and the team has on the decision-making of the surgeon during surgery.

Conclusions

This original and large cohort (84 foreign patients, 18 different native languages) demonstrates not only the feasibility but also the safety of awake surgeries for DLGG with the help of a trained interpreter for patients speaking foreign languages, with a particularly high rate of resumption of the patients’ professional activities at 3 months and good EOR. In case of complete absence of direct verbal communication, we also reported a slight but significant decrease in EOR, knowing that reoperation is possible to optimize the onco-functional balance. Further multicenter studies are needed to validate these preliminary data.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Duffau. Acquisition of data: Sellier. Analysis and interpretation of data: all authors. Drafting the article: Duffau, Sellier. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Duffau. Statistical analysis: Sellier. Study supervision: Duffau.

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