Chapter 17

Surgical Resection of Tumors Infiltrating Left Insula and Perisylvian Opercula — Utility of Anatomic Landmarks Implemented by Intraoperative Functional Brain Mapping

Francesco Signorelli, Domenico Chirchiglia, Rodolfo Maduri, Giuseppe Barbagallo and Jacques Guyotat

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http://dx.doi.org/10.5772/56568

1. Introduction

Tumors involving the insular lobe and perisylvian opercula of the dominant hemisphere are frequently managed conservatively regardless of their nature and clinical evolution, even if impending infiltration of nearby eloquent areas endangers their function. Our and other authors' experience (Duffau 2009, Duffau et al, 2000; 2001; 2006; 2009; Lang et al, 2001; Kim et al, 2002; Moshel et al, 2008; Saito et al, 2010; Sanai et al, 2010; Signorelli et al, 2010; 2011; Simon et al, 2009; Skrap et al, 2012; Yasargil et al, 1992; Wu et al, 2011; Zentner et al, 1996) demonstrate that wide surgical resection of these lesions are nonetheless feasible since tumor burden often displaces eloquent sites at the tumor boundaries (Duffau 2000; Duffau et al, 2000; 2001; 2006; 2009; Signorelli et al, 2010; 2011) and compensatory areas take over the lost function of infiltrated nervous tissue. However, accurate anatomic and functional knowledge of the sylvian fissure and structures located nearby is essential to perform any surgical act in this area, in order to decrease the risks of postoperative permanent deficits (Duffau 2009; Duffau et al, 2009; Moshel et al, 2009; Signorelli et al, 2010; 2011). Here we report our recent experience with tumors infiltrating left insula and perisylvian opercula and point out technical details helpful in guiding surgery through this region, with the purpose of locating and respecting neural and vascular structures and eloquent sites.

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2. Patients and methods

Our series includes 5 patients harboring a high grade and 10 patients harboring a low grade tumor involving left insula and perisylvian opercula, operated on between 2007 and 2011 at two institutions: the Neurosurgical Department at the Hôpital Neurologique et Neurochirurgical "Pierre Wertheimer" in Lyon, France, and the Neurosurgical Department of the University Hospital of Catanzaro, Italy. They were 8 males and 7 females (mean age 50.1 years) who presented with phasic troubles in 8 cases and seizures in all cases. Preoperative antiepileptic treatment was effective in all patients but one, although 3 other patients presented with more than 1 seizure/month. Aphasia was completely regressive in four patients, all LGG, and partially regressive in one HGG patient after administration of antiedema therapy and seizure control, while in 3 other HGG cases it was progressive at a thorough preoperative neuropsychologic evaluation which comprised Montreal-Toulouse and Boston tests (Dordain et al, 1983) repeated at 1-month. They were nonetheless judged to be good candidates for, and keen and motivated to undergo intraoperative language mapping.

Motor deficit was a presenting symptom in two patients. Moreover, in all HGG patients there were symptoms of intracranial hypertension (ICHT). ICHT had an acute onset in one patient which presented to our department with an intratumoral hemorrhage. This last patient displayed a right sensorimotor deficit and a right homonymous hemianopia. Surgical indication was established in lesions with a MRI appearance of LGG in two cases because of clinical and/or radiological tumor progression and in the other eight cases at the time of diagnosis.. All patients were right handed according to the Edimburgh Handedness Inventory (Oldfield, 1971). Gadolinium-enhanced T1-, T2- and FLAIR-weighted images revealed in all cases the infiltration of left insula. The tumor involved also fronto-parietal and temporal opercula in 9 cases, while frontal and temporal opercula or just parietal or temporal operculum were infiltrated respectively in three, two and one case. Moreover, the tumor infiltrated other paralimbic structures (i.e. fronto-orbital and/or temporo-polar areas) in four cases and limbic structures in two cases. In order to elucidate the relationships of the tumor with the vascular tree of left middle cerebral artery (MCA), in particular with lenticulostriate arteries, left carotid angiography was obtained for two patient. The other 13 patients underwent angio-CT scan and/or MRI angiography. The most lateral lenticulostiate branch was shown in 3 out of 15 cases originating from the post-bifurcation tract of M1, no more than 6 mm distal from the major bifurcation, while in the other cases it originated before or at the level of the MCA bifurcation but never from M2, in accordance with other author's experience (Moshel et al, 2008). Particular attention was also paid to the venograms, to determine the course of the superficial sylvian veins, which can hinder a wide dissection of the sylvian fissure, although generally sylvian fissure was approached subpially.

2.1. Surgical procedure

All patients underwent awake craniotomy using electrical stimulation mapping (ESM) of sensorimotor and language pathways, whose technique was described in detail elsewhere (Signorelli et al, 2010; 2011). Briefly, we applied a bipolar cortico-subcortical stimulation by an

http://dx.doi.org/10.5772/56568

electrode with tips 5 mm apart, which delivered biphasic square-wave pulses (1 ms per phase) with a frequency of 60 pulses per second. Cortical stimulation was started at 1 mA and the optimal current level for stimulation was set equal to that provoking segmental movements on the contralateral upper limb or face. The effective current intensity varied from 1 mA to 6 mA. Language tasks included counting, verbal and auditory naming (auditory task was used when testing anterior temporal lobe sites). Moreover, reading tasks were added when testing parietal or posterior temporal opercula. Neuronavigation was used for all patients for defining tumor boundaries and anatomic relationships with neural and vascular structures. Craniotomy was planned to include the whole perisylvian area from pars orbitalis of the third frontal gyrus to the postcentral sulcus, in order to expose the anterior (vallecula) and middle part (insular fossa) of the sylvian fissure, exposing also the superior temporal gyrus (T1). After performing ESM aimed at locating cortical language and sensorimotor areas, the superficial part of the lesion, which constantly infiltrated one or more of frontal, parietal and temporal opercula, was removed as to gain easy access to the depth of sylvian fissure, which was opened up to the postcentral sulcus with no need of retractors. In all our cases the tumor displaced M2 branches centrifugally, indicating to the surgeon the site on the insular surface where to start tumor debulking, after accomplishment of ESM in search of possible language areas. The removal of insular gyri, when not harboring language areas, was conducted medially up to the putamen, generally visible under the microscope as a gray, compact tissue with white strips located at the center of insula (Yasargyl et al, 1992), which we never found infiltrated in case of low grade tumors. However, while pushing medially tumor removal, we alternated surgical resection to subcortical stimulation starting at a distance of 2 cm laterally to the posterior limb of the internal capsule, as seen on neuronavigation, in order to identify and preserve subcortical motor pathways (Duffau 2009; Signorelli et al, 2010; 2011; Simon et al, 2009;). Subcortical stimulation is especially useful when pushing tumor resection above superior insular sulcus, where pyramidal fibers coursing through corona radiata are more superficial and anatomic landmarks to them lack. High attention was paid when pushing resection below the lenticular nucleus, at the level of the inferior limiting sulcus, where sublenticular fibers of the posterior limb of the internal capsule contain, in a forward-backward direction, the auditory and the optic radiations (Signorelli et al, 2010). At the level of the anterior part of the external capsule subcortical stimulation allowed the identification of the inferior occipito-frontal fasciculus inducing semantic paraphasias (Duffau 2009), which delimited the deep boundaries of tumor resection anteriorly. The temporal part of the same fasciculus marked the boundaries of the resection at the level of the temporal stem, preventing to open the temporal horn of the ventricle (Duffau 2009; Duffau et a, 2009). Of utmost importance is the recognition of the vascular anatomy. Short branches from MCA to the infiltrated insula can be interrupted because they supply the tumor, paying attention not to avulse them from the main vessel at the origin, which can lead to a lesion of the parent vessel wall. However, long perforators, supplying corona radiata, have to be respected to avoid ischemic injury to functional white matter (Duffau 2009; Lang et al, 2001; Moshel et al, 2008; Signorelli et al, 2010; 2011). During removal of limen insulae high attention has to be paid to lenticulostriate arteries, which originates mostly from the medial or superior aspect of MCA 6 mm or less around bifurcation and sometimes from

early M1 branches (Signorelli et al 2010). Lesion or even manipulation of them can lead to ischemic damage of the internal capsule.

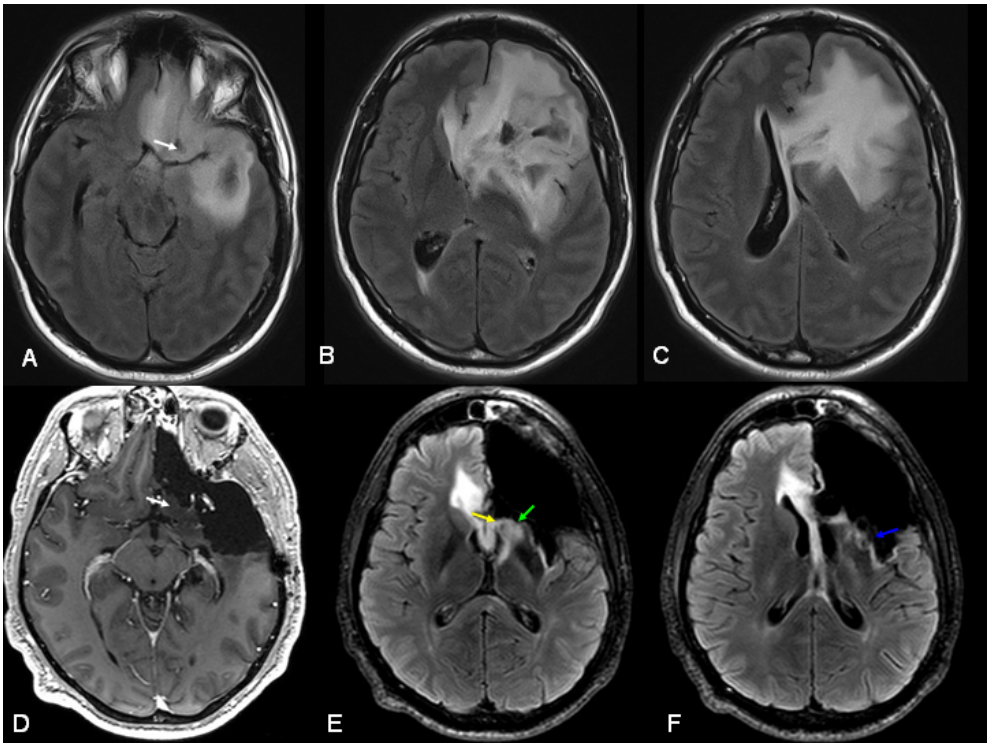


Figure 1. A, B,C: Preoperative FLAIR MR images of a low grade glioma infiltrating the left operculo-insular region and the fronto-orbital, including the perforated substance (white arrow), temporopolar and hyppocampal regions, type 5 B of Yasargil classification (Yasargil et al, 1992). **D**: Postoperative T1 gadolinium-weighted and **E,F**: Postoperative FLAIR MR images, showing the subtotal removal of the lesion. The boundaries of the resection are set based on anatomical (perforated substance, white arrow) as well as neurofunctional (subcallosal fasciculus, yellow arrow; inferior occipitofrontal fasciculus, green arrow; arcuate fasciculus, blue arrow) criteria.

3. Results

3.1. Electrophysiological results

ESM of the insular cortex surface resulted in speech arrest in 6 patients In 9 patients insula was free of language sites, as it was in all cases the cortex of opercular clefts and of superior and inferior insular clefts. For what concerns the location of eloquent sites at the level of the convexity, ESM located essential language sites on immediately perisylvian tumoral tissue in just one patient, while in the rest of cases functional areas were displaced at the periphery of

http://dx.doi.org/10.5772/56568

grossly infiltrated nervous tissue. The insular cortical areas whose stimulation evoked abdominal sensations such as nausea, borborygmi, belching (2 patients), chewing and tongue movements without speech arrest (4 patients) were not considered eloquent sites and removed because infiltrated by tumor. In one case ESM caused intraoperative partial tonic-clonic seizures, rapidly stopped pouring cold serum on the cortex. A gross total removal was achieved in all 6 patients that did not display infiltration of perisylvian or insular functional cortex and subcortical motor or language pathways. Stimulation of uncinate fasciculus during removal of an infiltrated limen insulae was done in 8 patients and was always uneventful. In all patients stimulation of the infiltrated white matter at the anterolateral border of the frontal horn of the left lateral ventricle (i.e. the subcallosal fasciculus) triggered limited spontaneous speech and/or perseverations with preservation of normal articulation and at the level of the anterior part of the external capsule as well as at the level of the temporal stem induced semantic paraphasias, which delimited the deep boundaries of tumor resection. Moreover, ESM was used to identify motor pathways inside corona radiata above the insular superior limiting sulcus, which represented the posterosuperior limit of tumor resection.

3.2. Clinical results

Ten patients had an immediate postoperative phasic aggravation, which lasted 1 to 2 months. At an overall mean follow up of 33 months (14-56 months) 10 patients are alive and keep a good quality of life, as assessed by the EORTC QLQ-C30 (Aaronson et al, 1993). One of them presents a tumor relapse, which causes an impairment of language performances, but she is still autonomous. Seven patients keep the same functional status they had before intervention, while two patients display an improvement of their neuropsychological performance after surgery. Three of the five patients diagnosed with a HGG died after a mean survival period of 16.7 months. Two of them had a mean HQSP (high quality survival period) of 18 months, while the last patient had a postoperative nucleo-capsular infarct, due to lenticulostriate arteries damage, engendering a definitive motor and phasic aggravation. Two other HGG patients, with a follow-up of 23 and 6 months respectively, are autonomous and have a good quality of life. For what concerns seizures outcome, 9 patients were ameliorated and 6 had no variation as regards to their preoperative status. On the postoperative MRI resection was in 6 cases grossly total, in 6 cases subtotal and in three cases partial owing to tumoral infiltration of functional tissue.

4. Discussion

Several well designed controlled studies indicate that the degree of surgical resection of brain gliomas, including those in highly eloquent areas, affects survival and quality of life of patients (Duffau 2009; Ius et al, 2012; Sanai et al, 2010) and there are some good reasons to treat aggressively such tumors: cytoreduction is effective in reducing the mass effect of the lesion and it can be assumed that it reduces also the contingent of neoplastic cells that can reproduce and give origin to tumor recurrence and invasion of eloquent areas or take anaplastic transformation (Duffau 2009; Ius et al, 2012; Sanai et al, 2010). Moreover, there are evidences that

aggressive removal of insular tumors can improve seizures control, which are their most frequent clinical manifestation (Taillandier et al, 2009). Authors pleading for an aggressive treatment of such tumors mostly think that it should be realized early after diagnosis to prevent clinical impairment and improve survival and recurrence free period of patients (Duffau 2009; Sanai et al, 2010).

Since the first report by Yasargil et al, other papers in the literature dealt with the surgical treatment of tumors infiltrating insular lobe (Duffau 2009, Duffau et al, 2000; 2001; 2006; 2009; Lang et al, 2001; Kim et al, 2002; Moshel et al, 2008; Saito et al, 2010; Sanai et al, 2010; Signorelli et al, 2010; 2011; Simon et al, 2009; Skrap et al, 2012; Yasargil et al, 1992; Wu et al, 2011; Zentner et al, 1996) and encompassed lesions with a variety of anatomical extensions. As a matter of fact, these series reported on purely insular tumors (type 3A of the Yasargyl's classification) as well as insulo-opercular (type 3B) and limbic-paralimbic lesions (type 5) involving both the dominant and the non-dominant hemisphere. Some authors reporting surgical removal of dominant-sided insular tumors did not find useful or did not employ awake surgery for language mapping (Hentschel et al, 2005; Lang et al, 2001; Simon et al, 2009; Yasargyl et al, 1992; Zentner et al, 1996), others demonstrated the utility of ESM mapping guided tumor resection, although seldom insula was found to harbor essential language sites (Duffau 2009; Duffau et al, 2001; 2009). In Duffau's series there were no permanent postoperative phasic deficits although he reported 10 cases of transient articulatory disorders (Duffau et al, 2000). In Hentschel and Lang's series there were 6 cases of transient speech troubles among patients with 3B tumors and in Zentner's series two of the 11 patients had a permanent postoperative aphasia (Hentschel et al, 2005; Zentner et al, 1996).

Our series, albeit small, is anatomically homogeneous in that focuses on tumors infiltrating the insular lobe of the dominant hemisphere and extended to the opercular region and, in six cases, also to adjacent deep perisylvian structures. Moreover, all patients were operated on while testing language function. The retrospective analysis restricted to these patients shows two basic findings: 6 out of 15 such patients, all harboring a LGG infiltrating the frontoparietal and temporal opercula, had speech arrest while stimulating insular cortex and these same patients did not have language sites on the opercular part invaded by the tumor. Conversely, the 9 patients for whom ESM of insular cortex did not trigger language troubles all harboured speech function on perisylvian opercula. They either had preoperative language troubles (4 cases), which did not hinder intraoperative language mapping, or a limited opercular infiltration, and no phasic deficits (5 cases).Thus, it can be speculated that for the 6 LGG patients displaying language sites on insula, this region compensated the opercular infiltration due to a plasticity phenomenon, which can be considered at least in part responsible for the preoperative regression of the phasic deficits. For the remaining patients the functional reorganization might not have occurred because of a limited opercular infiltration (1 patient) or because of a too extensive and rapid inactivation of perisylvian language sites by a high grade tumor. The compensatory role of left insula in case of infiltration of perisylvian language areas has already been pointed out as a function that must be preserved (Duffau et al, 2000). However, the compensatory potential of left insula seems to be highly variable on individual basis. There are mechanisms of cerebral plasticity taking place before the treatment of the lesion and both

http://dx.doi.org/10.5772/56568

in an acute stage and at distance from surgical intervention. This could be explained by the fact that sensorimotor and language functions seem to be organised within multiple parallel networks. Beyond the recruitment of areas adjacent to the surgical cavity, the long term reshaping could be related to progressive involvement of regions within the hemisphere omolateral to the lesion as well as of the contralateral hemisphere (Duffau, 2006).. In these cases functional reshaping involves association areas belonging to the same functional network of the lesioned area as it is the case for dominant insula and perisilvyan language sites. However, mechanisms of compensation are limited. One of such limits is that reorganisation seems to be more effective in secondary than in primary areas, as for SMA (Duffau, 2006). Moreover, if a damaged area is compensated by another region, a lesion of this newly recruited region will induce a permanent deficit, as it could be the case for dominant insulo-opercular gliomas. Thus, surgical resection should avoid infringement of insula if there are arguments indicating that it took over, at least partially, the lost function of perisylvian opercula. Taking into account these data may guide treatment of cerebral tumors in the dominant deep perisylvian area, broadening the surgical indication and the extent of tumor removal while lessening the rate of postoperative permanent deficits, and be useful for defining prognosis and rehabilitation programs.

Abbreviations

ESM: electrical stimulation mapping; HGG: high grade gliomas; ICHT: intracranial hypertension; LGG: low grade gliomas; MCA: middle cerebral artery; MRI: magnetic resonance imaging; T1: superior temporal gyrus.

Author details

Francesco Signorelli[1,2], Domenico Chirchiglia[3], Rodolfo Maduri[1], Giuseppe Barbagallo[4] and Jacques Guyotat[1]

1 “Magna Græcia” University, Department of Experimental and Clinical Medicine “G. Salvatore”, Chair of Neurosurgery, Catanzaro, Italy

2 Hospices Civils de Lyon, Hôpital Neurologique et Neurochirurgical, Department of Neurosurgery, Lyon, France

3 “Magna Græcia” University, Department of Medical and Surgical Sciences, Chair of Neurosurgery, Catanzaro, Italy

4 University of Catania, Chair of Neurosurgery, Catania, Italy

References

[1] Aaronson, N. K, Ahmedzai, S, Bergman, B, Bullinger, M, Cull, A, Duez, N. J, Filiberti, A, Flechtner, H, Fleishman, S. B, De Haes, J. C, et al. The European Organization for Research and Treatment of Cancer QLQ-C30: AQuality-of-Life Instrument for Use in International Clinical Trials in Oncology. Journal of the National Cancer Institute. (1993). , 85, 365-376.

[2] Dordain, M, Nespoulos, J. L, & Bourdeau, M. Lecours AR Verbal abilities of normal adults submitting to an aphasia linguistic protocol. Acta Neurol Belg. (1983).

[3] Duffau H, Capelle L, Lopes M, Faillot T, Sichez JP, Fohanno D. The insular lobe: physiopathological and surgical considerations. *Neurosurgery*. 2000;47:801-10.

[4] Duffau H, Bauchet L, Lehéricy S, Capelle L. Functional compensation of the left dominant insula for language. *Neuroreport*. 2001. 20;12:2159-63.

[5] Duffau H, Taillandier L, Gatignol P, Capelle L. The insular lobe and brain plasticity: Lessons from tumor surgery. *Clin Neurol Neurosurg*. 2006;108:543-8.

[6] Duffau, H. Lessons from brain mapping in surgery for low grade gliomas: study of cerebral connectivity and plasticity. In Medical Imaging and Augmented Reality. (2006). Online 978-3-54037-221-9Springer Berlin Heidelberg.

[7] Duffau H, Moritz-Gasser S, Gatignol P. Functional outcome after language mapping for insular World Health Organization Grade II gliomas in the dominant hemisphere: experience with 24 patients. *Neurosurg Focus*. 2009;27(2):E.

[8] Duffau, H. A personal consecutive series of surgically treated 51 cases of insular WHO Grade II glioma: advances and limitations. J Neurosurg. (2009). , 110, 696-708.

[9] Hentschel SJ, Lang FF. Surgical resection of intrinsic insular tumors. *Neurosurgery*. 2005;57:176-83.

[10] Ius T, Isola M, Budai R, Pauletto G, Tomasino B, Fadiga L, Skrap M. Low-grade glioma surgery in eloquent areas: volumetric analysis of extent of resection and its impact on overall survival. A single-institution experience in 190 patients: clinical article. *J Neurosurg*. 2012;117:1039-52.

[11] Kim YH, Kim CY.Current surgical management of insular gliomas. *Neurosurg Clin N Am*. 2012;23:199-206,

[12] Lang FF, Olansen NE, DeMonte F, Gokaslan ZL, Holland EC, Kalhorn C, Sawaya R. Surgical resection of intrinsic insular tumors: complication avoidance. *J Neurosurg*. 2001 Oct;95(4):638-50.

[13] Moshel YA, Marcus JD, Parker EC, Kelly PJ. Resection of insular gliomas: the importance of lenticulostriate artery position. *J Neurosurg*. 2008 Nov;109(5):825-34.

[14] Oldfield, R. C. The assessment and analysis of handedness: The Edinburgh inventory. Neuropsychologia. (1971). , 9, 97-113.

[15] Saito R, Kumabe T, Kanamori M, Sonoda Y, Tominaga T. Insulo-opercular gliomas: four different natural progression patterns and implications for surgical indications. *Neurol Med Chir (Tokyo)*. 2010;50:286-90

[16] Sanai N, Polley MY, Berger MS. Insular glioma resection: assessment of patient morbidity, survival, and tumor progression. *J Neurosurg*. 2010;112:1-9.

[17] Signorelli, F.; Guyotat, J; Elisevich, K. & Barbagallo, GM. Review of current microsurgical management of insular gliomas. *Acta Neurochirurgica.* 2010;152:19-26.

[18] Signorelli, F. Barbagallo, GM; Maduri R, Schonauer C, Guyotat, J, & Elisevich, K. Insular tumors. In Management of CNS Tumors, (2011). 978-9-53307-646-1Ed. Miklos Garami, InTech- Open Access Publisher- Rijeka, Croatia.

[19] Simon M, Neuloh G, von Lehe M, Meyer B, Schramm J. Insular gliomas: the case for surgical management. *J Neurosurg*. 2009;110:685-95.

[20] Skrap M, Mondani M, Tomasino B, Weis L, Budai R, Pauletto G, Eleopra R, Fadiga L, Ius T.Surgery of insular nonenhancing gliomas: volumetric analysis of tumoral resection, clinical outcome, and survival in a consecutive series of 66 cases. *Neurosurgery*. 2012;70:1081-93

[21] Taillandier L, Duffau H. Epilepsy and insular Grade II gliomas: an interdisciplinary point of view from a retrospective monocentric series of 46 cases. *Neurosurg Focus*. 2009 Aug;27(2):E8.

[22] Yasargil, M. G, Von Ammon, K, Cavazos, E, Doczi, T, Reeves, J. D, & Roth, P. Tumors of the limbic and paralimbic systems. Acta Neurochirurgica. (1992). , 147-149.

[23] Wu AS, Witgert ME, Lang FF, Xiao L, Bekele BN, Meyers CA, Ferson D, Wefel JS. Neurocognitive function before and after surgery for insular gliomas. *J Neurosurg*. 2011;115:1115-25.

[24] Zentner, J, Meyer, B, Stangl, A, & Schramm, J. Intrinsic tumors of the insula: a prospective surgical study of 30 patients. Journal of Neurosurg. (1996). , 85, 263-271.

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