Phenytoin reduces 5-ala mediated fluorescence in glioblastoma cells

Christopher Steele
Johnathan E Lawrence
Richard A Rovin
Robert J Winn
ST-001. PHASE 1 TRIAL OF A RETROVIRAL REPLICATING VECTOR (TOCA 511) IN RECURRENT HIGH GRADE GLIOMA PATIENTS DEMONSTRATES THE IMPORTANCE OF REAL-TIME MONITORING AND DURATION FOR DOSE-RELATED EVALUATION OF SAFETY AND EFFICACY
Manush Agli, Michael A. Vogelbaum, Douglas J. Jolly, Joan M. Robbins, Derek Osterberg, Carlos E. Ibañez, Harry E. Gruber, Noriyuki Kasahara, Krystof Bankiewicz, Timothy F. Cloughesy, Susan M. Chang, Nicholas Butovsky, Santosh Kesari, Clark Chen, Tom Mikkelson, Joseph Landolfi, E. Antonio Chiocca, J. Bradley Elder, Greg Foltz, Dan Pertschuk; 1Dept. of Neurological Surgery UCSF, San Francisco CA, USA; 2Cleveland Clinic, Cleveland, OH, USA; 3Tocagen Inc., San Diego CA, USA; 4Dept. of Medecine UCLA, Los Angeles CA, USA; 5Dept. of Neurosurgery UCSD, San Diego CA, USA; 6Moores Cancer Center UCSD, San Diego CA, USA; 7Dept. of Neurosurgery, Henry Ford Hospital, Detroit, MI, USA; 8Dept. of Medicine UCLA, Los Angeles CA, USA; 9Dept. of Neurosurgery UCLC, Los Angeles CA, USA; 10Dept. of Neurosurgery UCSF, San Francisco CA, USA; 11Dept. of Neurosurgery UCLC, Los Angeles CA, USA; 12Dept. of Neurosurgery OSU Med Center, Columbus, OH, USA; 13Swedish Neuroscience Institute, Seattle WA, USA; 14Dept. of Surgery Brigham and Womens Hospital, Boston MA, USA

We are conducting investigational dose escalation trials in patients with High Grade Glioma (HGG, NCT015156384 and NCT014707934), using a retroviral replicating vector (TOCA 511). TOCA 511 (vincamine amiretrovirus) encodes an optimized yeast cytosine deaminase that converts 5-fluorocytosine (5-FC) to the anti-cancer drug 5-FU in infected tumors. We report here results of a Phase 1/2 trial of direct intratumoral TOCA 511 administration to recurrent HGG patients, followed by repeat courses of oral 5-FC. Six TOCA 511 dose levels, escalated by halve logs, the mode of administration and the use of extended release 5-FC (TOCA 511) were investigated in 25 HGG patients to date. Treatment at all dose levels has been well tolerated. Post-treatment resection in two patients showed viral protein and DNA and RNA sequences including the CD gene. Hearing was preserved in 1 of 5 (20%) GTR patients, 0 of 2 NTR patients and 1 of 3 (33%) STR patients. Good facial nerve function (HBI & II) was achieved long term in 17 of 20 (85%) GTR patients, 11 of the 12 (92%) NTR patients and 22 of the 24 (92%) STR patients. Only the GTR group had HB IV or worse facial nerve function (3 patients). The rate of post-operative CSF leaks was 3.3% in Group A and 2.5% in Group B. CONCLUSION: The 2 dimensional view, increased working distance and novel instrumentation can result in a steep learning curve for endoscopic pituitary surgery. Increased experience should result in improved patient outcomes, particularly a decreased rate of diabetes insipids.

ST-003. FACIAL NERVE PRESERVATION SURGERY FOR LARGE VESTIBULAR SCHWANNOMAS: FUNCTIONAL AND TUMOR CONTROL OUTCOMES
Amjad Anaizi, Eric Gantwerker, Myles Pensak, and Philip Theodosopoulos; University of Cincinnati, Cincinnati, OH, USA

OBJECT: Large vestibular schwannomas pose a unique challenge of achieving surgical cure while maintaining normal facial nerve function. Facial nerve preservation surgery, defined as attempted maintenance of facial nerve function at the cost of residual tumor when adherent to the facial nerve or root entry zone, is a novel idea. We present our experience and evaluate functional outcomes and extent of resection. METHODS: We performed a retrospective review of patients treated surgically by a single surgeon team (PVT, MP) for large (Koo & 4) vestibular schwannomas between 2003-2012. We review the extent of resection, post-operative hearing and facial nerve function. We separated the patients into groups based on extent of resection (gross total, near-total and subtotal) and evaluated the tumor control rate and functional outcome. RESULTS: A total of 56 patients were included in the study. Four patients had received radiation treatment to their tumors prior to surgery. 18 patients underwent a retrosigmoid and 38 underwent a translabyrinthine approach. Hearing was preserved in 1 of 5 (20%) GTR patients, 0 of 2 NTR patients and 1 of 3 (33%) STR patients. Good facial nerve function (HBI & II) was achieved long term in 17 of 20 (85%) GTR patients, 11 of the 12 (92%) NTR patients and 22 of the 24 (92%) STR patients. Only the GTR group had HB IV or worse facial nerve function (3 patients). Long term tumor control was 100% for GTR, 92% for NTR and 83% for STR. 9 STR patients and 1 NTR patient received postoperative radiation therapy. Average follow-up was 33 months. CONCLUSION: Facial nerve preservation surgery is associated with increased chance of long term good facial nerve outcome. The rate of tumor progression following STR is 17%.

ST-002. ENDOSCOPIC PITUITARY TUMOR SURGERY: THE LEARNING CURVE
Amjad Anaizi, Christopher Taylor, Jennifer Kosty, Lee Zimmer, and Philip Theodosopoulos; University of Cincinnati, Cincinnati, OH, USA

INTRODUCTION: Endoscopic endonasal pituitary surgery is increasing utilized and is being passed on to the next generation of neurosurgeons. This approach can be technically challenging due to lack of 3 dimensional visualization, increased operative working distance and novel/different instrumentation. We present our experience with the exclusive endoscopic endonasal approach over the last 10 years. METHODS: We performed a retrospective review of patients who underwent an endoscopic endonasal pituitary tumor resection between 2003-2012 by a single neurosurgeon (PT, LZ). We assessed the extent of resection based on comparison of pre and post-operative imaging for each case. We reviewed complications including post-operative hypopituitarism, diabetes insipids and CSF leaks. We then compared these outcome parameters in the first half of patients operated on (group A) with the second half of patients (group B). RESULTS: A total of 240 patients with adequate follow up were included in the study. Average patient age in both groups was 31 years. F:M ratio in both groups was 1.15:1. In Group A 55.8% had a GTR and 44.2% had a STR. In Group B, 59.2% had a GTR and 40.8% had a STR. The rate of new post-operative pituitary dysfunction was 18.3% in Group A and 15% in group B. The rate of diabetes insipids was 12.5% in group A and 3.3% in group B (P < 0.01). The rate of post-operative CSF leaks was 3.3% in Group A and 2.5% in group B. CONCLUSION: The 2 dimensional view, increased working distance and novel instrumentation can result in a steep learning curve for endoscopic pituitary surgery. Increased experience should result in improved patient outcomes, particularly a decreased rate of diabetes insipids.

ST-004. NASAL CAVITY MALIGNANCIES INVOLVING THE SKULL BASE: IS THERE A ROLE FOR ENDOSCOPY?
Amjad Anaizi, Sanjeet Grewal, Philip Theodosopoulos, and Lee Zimmer; University of Cincinnati, Cincinnati, OH, USA

OBJECT: The role of endoscopy in the resection of malignant lesions remains controversial. Such malignancies are traditionally resected through transcranial approaches and any skull base involvement is addressed through transfacial approaches and any skull base involvement is addressed through transcranial or combined approaches. We present a series of patients with nasal cavity malignancies involving the skull base treated with purely endoscopic or endoscopic-assisted resections and offer an algorithm to assist in the appropriate selection of these patients. METHODS: We retrospectively reviewed the charts of patients with malignant nasal cavity lesions involving the skull base resected utilizing nasal endoscopy. RESULTS: A total of 9 patients were included in the series. M:F ratio was 3.5:1. Average age at time of surgery was 52 years. Pathology included Esthesioneuroblastoma, sarcoma, SNUC, melanoma, adenocarcinoma and myofibroblastic tumor. 2 patients (22%) had intra-orbital extension and 1 patient (11%) had prepyriform or frontal lobe extension. All patients had skull base involvement, 5 (56%) of which had intradural extension. 6 patients (67%) underwent a purely endoscopic resection and 3 patients (33%) had a combined approach. 6 (67%) patients had a GTR and 3 (33%) patients had subtotal resection. Average EBL was 780 ml. 67% of patients retained olfaction post-op. Average follow-up was 25 months. 6 (67%) underwent post-operative adjuvant treatment. Complications included 2 post-op CSF leaks. CONCLUSION: Nasal cavity malignancies involving the skull base can often be difficult to resect. Open transcranial approaches are effective, but can be associated with significant morbidity. We believe that endoscopic and endoscopic-assisted techniques offer a minimally disruptive alternative for the management of many of these lesions in appropriately selected patients.
ST-005. SURGICAL RESECTION FOLLOWING PRIMARY RADIATION TREATMENT FOR VESTIBULAR SCHWANNOMAS: DOES RADIATION IMPACT SURGICAL OUTCOMES AND EXTENT OF RESSECTION?

Amjad Anaziz, Myles Pensak, and Philip Theodossopoulos; University of Cincinnati, Cincinnati, OH, USA

OBJECTIVE: With the advent of highly focused delivery of radiation, an increasing number of vestibular schwannomas are being treated this way. A minority of these patients will fail this management strategy and require subsequent treatment. Early studies have shown poor post-operative facial function presumably due to radiation-induced fibrosis and adhesions to surrounding neurovascular structures. We present our experience with salvage surgical procedures following failed primary radiation treatment for vestibular schwannomas. METHODS: We performed a retrospective review of patients with unilateral vestibular schwannomas who underwent resection following failed primary radiation treatment. No patient had prior surgery for the same lesion and NF2 patients were excluded. We present patient demographic information, preoperative radiation treatment modality and preoperative facial nerve function. We review operative approach, pathology, extent of resection, facial nerve function, tumor control and complications. RESULTS: 5 patients with vestibular schwannomas previously treated with radiation underwent surgical resection. 3 patients received prior SRS and 2 patients received prior fractionated radiotherapy. Average time between radiation and surgery was 42 months. No patients had servicable hearing prior to surgery. All patients underwent a translabyrinthine approach. A gross total resection was achieved in 4 patients (80%), and a subtotal resection in 1 patient (20%). 3 patients (60%) had a good (HBI & II) post-operative facial nerve outcome. 2 patients had a HBI IV facial nerve palsy. Pathology revealed WHO I vestibular schwannoma in all patients. No patient had post-operative tumor progression with an average of 27 months follow up. CONCLUSION: Vestibular schwannomas that have failed primary radiation can present a difficult treatment dilemma to the surgeon. Although radiation effects can increase the potential for post-operative cranial nerve dysfunction and decrease the likelihood of achieving gross total resection, surgical resection with modern surgical technique is a safer and more effective than what earlier data would suggest.

ST-006. ENDOSCOPIC SURGERY FOR INTRAVENTRICULAR AND PARAVENTRICULAR TUMORS

Yoshiki Arakawa1, Yoo Kang1, Daiki Murata1, Ko-ichi Fujimoto1, and Yosuuki Minoh1; 1Department of Neurosurgery, Kyoto University Graduate School of Medicine, Kyoto, Japan; 2Department of Neurosurgery, Ohno Memorial Hospital, Osaka, Japan

BACKGROUND: Endoscopic management for the ventricular lesions has been widely applicable according to instrument’s development. In ventricular and paraventricular tumors, endoscopic biopsy has been less invasive and safer standard surgery. Here, we report our technique to resect intraventricular tumors with endoscopy. PATIENTS AND METHODS: Between 2007 and 2012, 40 patients with intraventricular tumors have been received endoscopic treatment. Our endoscopic system constitutes MINOP Modular Neuroendoscopy System (Aesculap), VISERA Pro video system with HD camera (OLYMPUS) and Navigation system (BrainLAB). Approach to lateral ventricle is performed through frontal craniotomy, in 3 cm diameter. The field exchange technique is composed of the dry field with evacuated CSF and the wet field with artificial CSF filled in. RESULTS: Tumor resection was accomplished in 12 patients. 2 patients received twice endoscopic operation. 4 patients were undergone clipping operation. The field exchange technique is composed of the dry field with evacuated CSF and the wet field with artificial CSF filled in. RESULTS: Tumor resection was accomplished in 12 patients. 2 patients received twice endoscopic operation. 4 patients were undergone clipping operation. Approach to lateral ventricle is performed through frontal craniotomy, in 3 cm diameter. Camera (OLYMPUS) and Navigation system (BrainLAB). RESULTS: Tumor resection was accomplished in 12 patients. 2 patients received twice endoscopic operation. 4 patients were undergone clipping operation. Approach to lateral ventricle is performed through frontal craniotomy, in 3 cm diameter. Camera (OLYMPUS) and Navigation system (BrainLAB). Approach to lateral ventricle is performed through frontal craniotomy, in 3 cm diameter. RESULTS: Tumor resection was accomplished in 12 patients. 2 patients received twice endoscopic operation. 4 patients were undergone clipping operation. Approach to lateral ventricle is performed through frontal craniotomy, in 3 cm diameter. Camera (OLYMPUS) and Navigation system (BrainLAB). Approach to lateral ventricle is performed through frontal craniotomy, in 3 cm diameter.

ST-007. ORBITAL METASTASES AS PRIMARY CLINICAL MANIFESTATION OF LUNG CANCER: CASE REPORT AND LITERATURE REVIEW

María Blaga, Maurizio Paulis, Giuseppe Orunesu, and Salvatore Serra; Department of Neurosurgery, San Francisco Hospital, Nuoro, Sardinia, Italy

INTRODUCTION: Orbital metastases are an infrequent etiology of adult proptosis; approximately 3–7% of orbital biopsies have demonstrated a metastatic tumour, and this diagnosis is often unexpected. Between 2% and 5% of cancer patients will develop an ocular or orbital metastasis. In 25% of these, it is the presenting sign of malignancy. Frequently, this presents a diagnostic challenge and represents a poor prognosis. METHODS: A 50-year-old man presented with swelling of the eyelid margin, local pain and proptosis of his right eye. Past medical history was unremarkable and the patient took no medications. A CT scan revealed extensive bony destruction of the orbital roof and anterior skull base. A right fronto-orbital approach was used for total removal of the osteolytic tumor. RESULTS: A simple thorax x-ray reveals atelectasia on the lower left lobe and via a bronchoscopy we found an endobronchial mass. We obtained a biopsy and the resulting diagnosis was a spinocellular carcinoma, confirming that this is the originating tumor for the orbital metastasis. Histopathological and cytological study confirmed the diagnosis of an orbital metastases associated with abscess. Postoperative MRI demonstrate a total removal of the tumour. Three months after surgery the patient’s condition is deteriorating and currently is receiving palliative care. CONCLUSIONS: An orbital tumor with proptosis and/or ptosis with a history of cancer should be evaluated for orbital metastasis. Prognosis can be poor, and thus treatment is sometimes palliative in nature, intending to slow the progression of the disease instead of providing a cure.

ST-009. miR-21 IN THE EXTRACELLULAR VESICLES (EVs) OF CEREBROSPINAL FLUID (CSF): A PLATFORM FOR Glioblastoma Biomarker Development

Johnny Akers1, Varla Ramakrishnan2, Ryan Kim3, Johan Skog1, Ichiro Nakano2, Sandeep Pingel4, Julia Ulmiaker1, Gabriele Calaminus9, Xandra Breakfield3, Fred Hochberg3, Erwin Van Meer4, Bob Carter1, and Clark Chen1; 1University of California San Diego, La Jolla, CA, USA; 2Ohio State University, Columbus, OH, USA; 3Massachusetts General Hospital, Boston, MA, USA; 4Emory University, Atlanta, GA, USA; 5Eosom Diagnostics, New York, NY, USA

Glioblastoma cells secrete extra-cellular vesicles (EVs) containing microRNAs (miRNAs). Analysis of these EV miRNAs in the biofluids of afflicted patients represents a potential platform for biomarker development. However, the analytic algorithm for quantitative assessment of EV miRNA remains under-developed. Here, we demonstrate that the reference transcripts currently used for quantitative PCR (including GAPDH, 18S rRNA, and hsa-miR-103) were unreliable for assessing EV miRNA. In this context, we quantitated EV miRNA in absolute terms and normalized this value to the input EV number. Using this method, we examined the abundance of miR-21, a highly over-expressed miRNA in glioblastomas, in EVs. In a panel of glioblastoma cell lines, the cellular levels of miR-21 correlated with EV miR-21 levels (p < 0.05), suggesting that glioblastoma cells actively secrete EVs containing miR-21. Consistent with this hypothesis, the CSF EV miR-21 levels of glioblastoma patients (n = 13) were, on average, ten-fold higher than levels in EVs isolated from the CSF of non-oncologic patients (n = 13, p < 0.001). Notably, none of the glioblastoma CSF harbored EV miR-21 level below 0.25 copies per EV in this cohort. Using this cut-off value, we were able to prospectively distinguish CSF derived from glioblastoma patients (Sensitivity = 87%; Specificity = 93%; AUC = 0.91, p < 0.01). Our results suggest that CSF EV miRNA analysis of miR-21 may serve as a platform for glioblastoma biomarker development.

ST-010. ROLE OF SURGERY IN PATIENTS WITH INTRACRANIAL NON GERMINOMATOUS GERM CELL TUMORS (NGGCT) TREATED ACCORDING TO SIOP CNS GCT 96 PROTOCOL WITH RESPECT TO THE SITE AND TIME OF RESECTION

Thomas Czech1, James Nicholson2, Didier Frappaz3, Rolf-Dieter Kortmann3, Claire Alapetite4, Maria-Luisa Garré5, Umberto Ricardi, Frank Saran6, and Gabriele Calaminus7; 1Medical University Vienna, Vienna, Austria; 2Addenbrookes Hospital, Cambridge, UK; 3Centre Leon Bérard, Lyon, France; 4Medical University, Leipzig, Germany; 5Institut Curie, Paris, France; 6Gaslini Children’s Hospital, Genova, Italy; 7Medical University, Torino, Italy; 8Royal Marsden Hospital, London, UK; 9Medical University, Münster, Germany

BACKGROUND: Data from SIOP CNS GCT 96 and other trials suggest improved outcome with delayed resection of residual tumour in patients with intracranial NGGCTs. The relevance of tumour resection on the treatment algorithm has not been evaluated. METHODS: Until 31.05.2012, 201 patients with NGGCT were treated according to SIOP CNS GCT 96. Median
INTRODUCTION
Seizures are the most frequent presenting symptom in patients with low-grade tumors and are more prevalent when the lesion is located in or around the temporal lobe. Resection strategies in these patients vary between lesionectomy and epilepsy operations with no clear consensus on optimal approaches. METHODS: A prospectively compiled database of epilepsy and tumor patients was used to identify patients who underwent surgical resection of a gial neoplasm but then developed epilepsy, or who presented with epilepsy and were found to harbor a low grade neoplasm. Seizure frequency, histology, type of surgical resection and outcomes were compiled. RESULTS: Of 235 patients that underwent cranial procedures for epilepsy and 79 patients with low/intermediate grade gliomas, 14 (6%) and 20 (25%) respectively had tumoral epilepsy. Etiology was WHO grade 1 gliomas (DNET, Gangliogliomas, JPA) in 33%, grade 2 gliomas in 36% and grade 3 in 30%. One epilepsy patient had a PNET. Median age was 37 years (22 male). Most common locations were temporal 36%, 7 marginal 5, mesial 3 and extending to insular cortex and peri-rolandic - 7% (SMA in 5; lateral in 4). In the epilepsy group, following lesionectomy in 3 and tailored resections in the majority, seizure outcomes were Engel class one in all (1A-10, 1B-2) except for one (class 3). In the tumor group 7 additional resections were performed due to seizure recurrence – all related to residual or recurrent tumor after initial surgery. Outcomes were 1A in 18, 1B, 1C and 2A in each. CONCLUSION: We used an aggressive surgical intervention targeting the lesion except where medial temporal structures were involved, where a subtotal temporal lobectomy was performed. The excellent outcomes (Engel class 1A in 94%) relate to aggressive initial surgical resection and re-resection in the context of recurrence.
were treated by complete (CR) or partial resection (PR) followed by radio-
otherapy. The trajectory should avoid sulci, cortical veins or ven-tricular system. After system in the inside were irrigated repeatedly with 0.1 - 0.2 ml saline using thin plastic tube to ensure hemostasis. RESULTS: In all patients appro-
appropriate samples for pathological diagnosis were obtained. The diagnoses were 11 gliomas (pilocytic 1, grade II 3, grade III 3, grade VI (GBM) 2, high grade 1, gliat tumor 1) 3 lymphomas, 1 germinoma and 1 multiple sclerosis. There were no symptomatic bleeding nor neurological complications. CONCLUSIONS: The detailed planning, stereotactic biopsy was safely per-
formed even from brainstem. Trajectories other than from frontal can be also considered for lessons. Repeated irrigation with saline might effective to prevent symptomatic bleeding.

ST-015. SPECIFIC TREATMENT CONSIDERATIONS AND OUTCOME DATA IN ELDERLY GLIOMA PATIENTS - A SINGLE CENTER EXPERIENCE
Markus Hoffermmann, Lukas Bruckmann, Kariem Mahdy Ali, Mar ten Asslaber, Franz Payer, and Gord von Campe; Medical University of Graz, Graz, Austria

BACKGROUND: Although High Grade Gliomas (HGG) are significantly more frequent in patients older than 65 years of age, most clinical studies so far only included young or elderly population. It is well known that age itself is an independent risk factor in glioma patients and individualized treatment is mandatory, given the prevalence of comorbidities in the elderly. Recent multi-center clinical trials have tried to define the role of different adjuvant thera-
pies, but the role of surgery, especially regarding extent of resection, remains a matter of lively discussion. MATERIALS AND METHODS: A retrospective clinical data analysis of 150 patients (90M, 60F) over 65 years with supratentorial gliomas (WHO-IV:137, WHO-III:11, WHO-II:2) was performed, with emphasis on survival data, adjuvant therapies and neurosurgical intervention. RESULTS: Mean progression free survival was 6.8 months and mean overall survival (OS) was 8.6 months. In 156 surgical procedures (GTR:43, STR:32, PR:57, biopsies:30, reoperations:14) we experienced a mortality rate of 3.3% and morbidity of 18.3%, highest in STR. In the High Grade Glioma sub-
group, GTR and STR led to significantly improved median OS compared to PR, biopsy or no surgical procedure (15 and 12 months vs. 4, 4 and 2 months; p < 0.001). Reoperations were performed in selected cases of HGG (n = 10) and these patients showed significantly higher OS (21 vs. 7 months median OS, p = 0.035). Regarding mean OS, adjuvant therapy according to the STUPP-protocol proved to be more efficient (21.4 months, p = 0.001) than radio- or chemotherapy alone (3.3 and 8.6), concomitant chemoradio-
therapy (6.3) or best supportive care (3.4) but not significantly different from that of patients followed by chemotherapy (18.6 months, p = 0.94). CONCLUSION: Our single center experience provides helpful information on the value of neurosurgical treatment and its impact on outcome in elderly glioma patients, despite limitations regarding treatment heterogeneity. It sup-
ports the need for further prospective studies in this age group.

ST-016. COMPLETE, BUT NOT PARTIAL RESECTION OF RECURRENT GliOBLASTOMA ProlongS SURVIVAL AFTER RELAPSE WITHOUT IMPAIRMENT OF FUNCTIONAL OUTCOME
Christine Jungk, Bernhard Beigel, Vitali Abb, Christel Herold-Mende, and Andreas Unterberg; Department of Neurosurgery, University Hospital Heidelberg, Heidelberg, Germany

OBJECTIVE: Standard of care in newly diagnosed glioblastoma (GBM) is maximal safe tumor resection followed by radio (RT)- and chemotherapy (CHT). At tumor relapse, however, standard of care, particularly the value of re-resection, is still under debate. We addressed the need for further prospective studies in this age group. Of the cases the biopsy was done through frontal lobe, but in some cases through temporal lobe or through cerebellum. The samples were taken deeper and nearer regions of the designed targets with same trajectory, also. If there were cysts, aspiration of the cyst was performed as much as possible. The trajectory should avoid sulci, cortical veins or ven-tricular system. After system in the inside were irrigated repeatedly with 0.1 - 0.2 ml saline using thin plastic tube to ensure hemostasis. RESULTS: In all patients appro-
appropriate samples for pathological diagnosis were obtained. The diagnoses were 11 gliomas (pilocytic 1, grade II 3, grade III 3, grade VI (GBM) 2, high grade 1, gliat tumor 1) 3 lymphomas, 1 germinoma and 1 multiple sclerosis. There were no symptomatic bleeding nor neurological complications. CONCLUSIONS: The detailed planning, stereotactic biopsy was safely per-
formed even from brainstem. Trajectories other than from frontal can be also considered for lessons. Repeated irrigation with saline might effective to prevent symptomatic bleeding.

ST-017. COMPARATIVE STUDY OF LONG-TERM RESULTS FOR INTRACRANIAL MENINGEAL HEMANGIOPERICYTOMA AND MALIGNANT MENINGIOMA IN SINGLE INSTITUTION: FOCUSED ON SURVIVAL AND LOCAL CONTROL
Jeong Hoon Kim, Young Hyun Cho, and Chang Jin Kim; Asan Medical Center, Seoul, Republic of Korea

INTRODUCTION: Both hemangiopericytoma (HPC) and malignant me-
ningioma (MM) are a rare tumor of meningeal origin that behaves aggres-
sively with a high rate of local recurrence and distant metastases. Two diseases are clinically very similar but there are no comparative study for long term outcome between HPC and MM. Therefore, we present our experiences. MATERIAL AND METHODS: We retrospectively reviewed pathologically proven 30 patients of HPC and 39 patients of MM treated from 1991 to 2006 with at least 5 years follow-up period. Data including clinical character-
istics, treatment modalities, recurrences and survival were reviewed. Statistical analysis was done with regards to overall survival (OS) and recurrence free survival (RFS) using Kaplan-Meier survival analysis. RESULTS: The median age at presentation of HPC and MM was 43.0 and 52.0 years. Twenty seven of 30 (90%) in HPC and 28 of 39 (72%) in MM underwent complete resection (Simpson Grade 1 and 2). The 3-, 5-, and 10-year overall survival rates of HPC were 100%, 100%, and 43%, and those of MM were 87%, 64%, and 32%, respectively. The 3-, 5-, and 10-year recurrent rates of HPC were 23%, 40%, and 56% and those of MM were 47%, 49% and 75%. Adjuvant radiotherapy (RT) after surgical resection was an important signif-
ificant prognostic factor for OS and RFS (p = 0.026, p = 0.024), but complete resection was not in HPC (p = 0.565, p = 0.226). In contrast, complete resec-
tion was important prognostic factor for OS and RFS (p = 0.004, 0.047) although adjuvant RT was not significant factor in MM (p = 0.432, p = 0.742). CONCLUSION: We conclude that both HPC and MM are very aggres-
sive tumor with high recurrent and low survival rate. While complete re-
section is best treatment modality in MM, surgical resection with adju-
vant RT is best treatment modality in HPC. Long-term and meticulous follow-up is mandatory for local recurrences and distant metastases.

ST-019. MRI-BASED HIGH RESOLUTION MAPS FOR PLANNING/GUIDING HIGH PRECISION PROCEDURES IN BRAIN TUMOR PATIENTS
Yael Mardor1,2, Ouzi Nissim1, Yuval Grober1, David Guez1, David Last1, Drane Danelieh1,2, Chen Hoffmann1,2, Dvora Nass1, Alisa Talianski1, Roberto Spiegelmann1,2, Zvi Cohen1,2, and Leor Zach1,2; Sheba Medical Center, Ramat Gan, Israel;1 Tel Aviv University, Tel Aviv, Israel

BACKGROUND: Conventional MRI is currently unable to differentiate tumor from non-tumoral tissues (such as radionecrosis). We have developed delayed contrast extravasation MRI for calculating high resolution maps clearly differentiating tumor from non-tumoral tissues. Here we demonstrate the application for targeting improved high precision procedures. METHODS: 38 patients with 33 patients with 33 patients underwent delayed post chemo-
radiation/radiosurgery were scanned by delayed contrast extravasation MRI prior to surgery. High resolution maps were calculated from T1-MRI acquired 2 and 7 min post contrast injection. 44 stereotactic biopsies planned using the maps were acquired from 17 patients. En-Black samples were acquired from 13 and gross total samples were acquired from 13. Histological analysis was then compared with the pre-surgical maps for all patients. RESULTS: The maps showed two primary populations: the delayed contrast accumulation population (red in the maps) and the delayed contrast clearance population (blue). In all cases, samples obtained from blue regions in the maps consisted of morphologically active tumor while samples obtained from red regions
AGGRESSIVE SURGICAL MANAGEMENT OF INSULAR TUMORS

INTRODUCTION: Aggressive surgical resection of insular tumors is neurosurgically challenging due to anatomically and functionally complex cortical structure of the insula. The effects of insular neoplasms on surrounding architecture further complicate resection. Some advocate stereotactic biopsy followed by radiotherapy. However, we demonstrate that aggressive surgical management of insular tumors can be achieved with minimal morbidity using specialized microsurgical techniques.

METHODS: We performed a retrospective review of all patients undergoing surgical resection for insular tumors at our institution since 2006 (n = 12). Follow-up ranged from 3 months to 6 years (median = 5 years). Each patient underwent circumferential microsurgical dissection and embolic tumor removal. All procedures were performed by a single neurosurgeon. The surgical procedure included skeletonization of insular branches of the middle cerebral artery and preservation of perforators (lenticulostriate arteries). Patients presenting with intractable seizures underwent Wada test and PET imaging prior to surgery. Postoperatively, surgical outcomes were characterized by the following: 1) histological diagnosis, 2) control of seizures, 3) extent of tumor removal 4) development of new neurological deficits, and 5) long-term outcomes.

RESULTS: Nine patients had insular tumors histologically classified as gliomas; remaining lesions included metastases and primary CNS lymphoma. All patients underwent gross total resection. No patient had persistent motor or speech deficit on long-term postoperative follow-up. All patients with refractory seizures (n = 5) had good seizure control from the comprehensive resection. Low-grade gliomas involving the insular lobe remain confined. Due to the expansive growth of insular gliomas, the lenticulostriate vessels are extensively shifted and displaced medially. Insular gliomas demonstrate a stereotypic skull border medially, which microsurgically aids in creating the plane of resection. CONCLUSION: Our neurosurgical technique optimizes volumetric resection of insular tumors with preservation of surrounding neurovascular structures, preventing long-term neurologic morbidity. With new technical refinements in imaging and neuronavigation, radical removal of insular tumors is feasible with minimal morbidity.
Increased EOR resulted in better PFS for diffuse astrocytoma (P = 0.012): when RV was greater than 8,000 mm³, the 1-year survival rate was 85.3%. Higher RV was significantly associated with poorer survival (p = 0.012): when RV was greater than 8,000 mm³, the 1-year survival rate was 35.0%. When RV was less than 8,000 mm³, 1-year survival rates in patients where EOR was greater than 90%, 1-year survival was in excess of 80%. EOR and RV were found to be significant predictors of survival in patients with malignant gliomas near the PT.

INTRODUCTION: Malignant glioma represent a relevant therapeutic issue and the value of extensive surgical resection remains debated; recent evidence suggests that radical removal is associated with better survival. An interesting tool for identifying tumor tissue and increasing the extent of surgery is represented by fluorescence-guided resection, taking advantage of metabolic and structural changes induced by 5-aminolevulinic acid (ALA), a natural precursor of heme biosynthetic pathway. METHODS: The present experience is related to 48 patients affected by malignant glioma (28 newly diagnosed and 20 recurrent tumors): 42 glioblastoma (GBM), 4 anaplastic oligodendroglioma, 1 oligodendrogioma I WHO and 1 pleomorphic xanthoastrocytoma. All patients underwent preoperative and early postoperative MRI, using contrast-enhanced sequences. All patients were selected for fluorescence-guided resection. An oral dose of 20 mg 5-ALA / kg bw was administered to each patient. Microsurgical resection was performed by an operating microscope enabled to visualize the fluorescence. All the patients, as first line treatment, have been submitted to radiotherapy and chemotherapy; second and in some cases third line treatments were utilized in recurrent cases. RESULTS: In more than 90% of patients tumor tissue showed intraoperative red fluorescence; mainly in recurrent GBM, when MRI documented heterogeneous tumors with enhancing areas mixed with gliotic scars, fluorescence-guided surgery allowed a better definition of active tissue, with net margins from perilesional “healthy” brain. Early postoperative MRI confirmed gross total resection in 80% of the patients. In the present experience the procedure did not determine any relevant additional neurological deficit. Considering overall survival of recurrent patients we obtained a median extension of at least 9.0 months (4 – 16 + months). CONCLUSIONS: Fluorescence-guided surgery improves tumor detection and allows extended resection of malignant glioma, without any relevant impact on neurological status, resulting helpful mainly in the recurrent setting with a consistent effect on overall survival.

INTRODUCTION: The optimal surgery for malignant gliomas, at present, is maximal tumor resection without deterioration of neurological function. We evaluated the contribution of using tractography-integrated navigation system and motor evoked potentials (MEPs) to surgical and functional outcomes. METHODS: Subjects comprised 50 patients who underwent resection for malignant glioma near the pyramidal tract (PT) in our hospital. Diffusion tensor imaging (DTI) was performed using a 3-T magnetic resonance scanner, and DTI-based tractography of the PT was loaded into the navigation system for intraoperative guidance. If possible, silicone catheters as fence posts were inserted along the tumor boundaries, avoiding the course of the PT before removal. Cortical MEPs were monitored intermittently during resection. When the line of resection closely approached the PT, subcortical MEPs were used to identify proximity to the PT by observing motor responses. When a response was elicited, removal was abandoned to ensure preservation of the motor function. RESULTS: DTI-based tractography of the PTs was performed successfully in all patients. Fence post techniques using a tractography-integrated navigation system were applied in 46 patients. This fence post technique was useful to clarify the resection plane before resection, and to resect the tumors safely and easily. Amplitudes of cortical MEPs after total resection were 60-140% of those obtained before surgery, and no subcortical MEPs were observed at 20-mA stimulus intensity in eight patients throughout tumor resection, the other 42 patients showed obvious responses of subcortical MEPs at ≥20 mA. The degree of resection was total in 22 patients, subtotal in 13, and partial in 15. At one month postoperatively, only one patient showed worsened motor function because of tumor progression. CONCLUSION: A tractography-integrated navigation system and MEPs are useful for preserving motor function during tumor resection in patients with malignant gliomas near the PT.
with non-resectable tumors (p = 0.399 and p = 0.356, respectively). CONCLUSION: Maximal safe resection likely provides a greater benefit to glioblastoma patients with resectable tumors than to those with non-resectable tumors. Surgical resection may confer a survival benefit by decreasing the degree of compression on the brain and by reducing the volume of viable tumor.

ST-027. FLUORESCENCE GUIDE SURGERY IN HIGH GRADE GLIOMAS USING A HIGH-DEFINITION EXOSCOPE SYSTEM: AN ALTERNATIVE MIcroSCOPE
Jose Piquer1, Jose Luis Llacer, Vicente Revira, Pedro Riesgo, and Antonio Cremades; Hospital Universitario de la Ribera, Alzira, Valencia, Spain

INTRODUCTION: Fluorescence-guided microsurgical resections of high-grade gliomas using 5-aminolevulinic acid (5-ALA) have proved to be superior to conventional microsurgery. An optical device, usually a modified microscope, is needed for these procedures. However, an exoscope may be implemented for fluorescence techniques. OBJECTIVE: We present the use of an exoscope to perform tumor resection guided by 5-ALA fluorescence in 21 consecutive patients with high-grade glioma and 2 neuroravagination guided biopsy. METHODS: Twenty-five these were operated using a 5-ALA fluorescence exoscope system. Tumor fluorescence intensity was quantified with pre- and postoperative volumetric magnetic resonance imaging in non biopsy cases. RESULTS: In non biopsy cases the age range in our series was 20 to 79 years, with a median of 56 (interquartile range = 45-66). Histological analysis indicated that 14 had glioblastoma multiforme, 2 grade III oligodendroglioma and 1 anaplastic astrocytoma, 3 metastases and 1 low grade astrocytoma. Total resection was achieved in 15 cases, subtotal resection was performed in 5 patients, and in one case, the result was a partial resection. There was no perioperative mortality. The median fluorescence intensity, on a scale of 1-5, was 4.5 in the GBM group (IQR = 4.5-5), 3 (IQR = 2.5-3.5) in the cases of anaplastic glioma and 2.5 (IQR = 2.25-2.75) for the oligodendrogliomas. Of the three metastases, one showed a level 4 degree of fluorescence. In the two biopsy cases, 1 was an anaplastic astrocytoma and 1 a glioblastoma multiforme. In both cases the samples obtained from tumor were fluorescence. CONCLUSIONS: An exoscope can be also be used to for fluorescence-guided surgery and with 5-aminolevulinic acid (5-ALA) and neuronavigation guided biopsy. With an important advantage of low cost allows the surgeon to perform collaborative surgeries and adds agility to the procedure.

ST-028. PREOPERATIVE nTMS GENERATED MOTOR AND LANGUAGE MAPS: FEASIBILITY AND OUTCOME
Rogier Kottas, Nicholas Lever, Arjint Prabhu, Raymond Sawaya, Jeffrey Weinberg, Ganesh Rao, Sudhakar Tummala, and Catherine Tilley; University of Texas MD Anderson Cancer Center, Houston, TX, USA

INTRODUCTION: The management of brain tumors adjacent to speech and motor areas presents a surgical challenge. The goals are maximal safe resection and preservation of neurological function. Pre-surgical functional information about the cortical and subcortical areas at risk is crucial for the avoidance of neurological deficits during tumor surgery. Intraoperatively direct electrical stimulation (DES) is the “gold standard” to identify and pre-avoidance of neurological deficits during tumor surgery. Intraoperatively decreasing the degree of compression on the brain and by reducing the volume of viable tumor.

ST-029. MINIMALLY INVASIVE SURGICAL RESECTION OF SUBCORTICAL TUMORS USING THE SIX PILLARS SYSTEM
Richard Row1 and Amin Kassam2; 1Marquette General Hospital, Marquette, MI, USA; 2The Ottawa Hospital, Ottawa, ON, Canada

The neurological cost of access to subcortical tumors often precludes surgical removal, thus denying these patients a biologically meaningful intervention available to their counterparts with more superficially located lesions. By integrating the latest technologies from mapping, image guidance, access, optics, resection and therapeutic platforms, the Six Pillars System optimizes the minimally invasive approach to deep tumors. At the heart of the system is the FDA approved BrainPath device—a 13.5 mm tubular retractor that is directed to the tumor via a trans-sulcal trajectory designed to minimize shear force to the intervening white matter fiber tracts. The first surgeries in the United States using the Six Pillars System were performed at Marquette General Hospital. To date, 17 patients with tumor have been treated. There were six men and eleven women. Five patients harbored primary tumors (two glioblastomas and three grade III astrocytomas). Twelve patients had metastatic tumors. Following surgery, five patients improved neurologically, nine were unchanged, and one patient had a persisting deficit. Two patients had postoperative seizure. No patient developed a postoperative infection. One patient expired, one month after surgery. The average length of stay for patients treated with the Six Pillars System was 2.25 days, compared to 4.82 days for patients undergoing open craniotomy. The authors conclude that the minimally invasive approach to subcortical tumors using the Six Pillars System is safe and effective for appropriately selected patients.

ST-030. LOW-DOSE RATE IODINE-125 BRACHYTHERAPY IN RECURRENT MALIGNANT GLIOMAS
Christoph Schwatta1, Alexandre Romagna1, Niklas Thon1, Jorg-Christian Tom1, Silke Birgit Schwarz2, and Friedrich-Wilhelm Kreitl3; 1Department of Neurosurgery, Munich, Bavaria, Germany; 2Department of Radio-Oncology, Munich, Bavaria, Germany

OBJECTIVE: Prognosis of recurrent malignant gliomas (WHO III and IV) is dismal and despite numerous efforts postresection survival (PRS) remains short. This pivotal study evaluates the effectiveness and treatment-associated morbidity of low-dose-rate iodine-125 stereotactic brachytherapy (SBT) in highly selected patients with circumscribed tumor recurrence. METHODS: Data of patients with treatment between 2003 and 2011 were prospectively collected and retrospectively analyzed. Indications for SBT were histologically verified recurrent gliomas WHO III or IV with a diameter of <6cm based on MRI and 18FET-PET, and a KPS ≥70%. Biomarker status included MGMT-methylation, IDH1/2 mutations, LOH 1p/19q. SBT was performed via temporary iodine-125 seed implantation. Reference dose was 50 Gy, dose rates were low (<5 cGy/h). Date of last follow-up (FU) was 02/2012. Survival analysis was performed with the Kaplan-Meier method. RESULTS: 71 patients (35 males, 36 females) were included. Median age at seed implantation was 52 years, the median KPS was 90%. All patients had received prior treatment. Histological diagnoses included 41 glioblastomas WHO IV, 20 astrocytomas WHO III, 9 oligoastrocytomas WHO III, 1 and 10 oligodendroglioma WHO III. The median tumor volume was 2.5 cm3 and the median treatment time was 450 hours. The median FU was 34 months. Median PRS after SBT was 9.5 months (C95% 7.6-18.4) and 25.7 months (C95% 11.5-42.3) for WHO IV and III tumors. Favorable prognostic factors for PRS after SBT were patient age at SBT (p = 0.002) and LOH 1p/19q (p = 0.04). Neither tumor grade, nor MGMT-methylation, nor IDH1/2 mutations had any significant impact. Transient morbidity was seen in 17% of patients, no permanent morbidity was found. CONCLUSIONS: Low-dose-rate Iodine-125 SBT is an attractive additive local treatment option for highly-selected patients with recurrent malignant gliomas who had previously undergone multimodal therapy. SBT efficacy is seemingly independent from MGMT-methylation and IDH1/2 mutation status.

ST-031. THE ROLE OF SURGERY FOR ANAPLASTIC GLIOMAS WITH IDH GENE MUTATION
Yukishiro Sonomoto1, Ichiyoshi Shihabara1, Ryuta Saito1, Masayuki Kanamori1, Tenkai Kuma1, and Teji Tomunaga1; 1Tohoku University, Sendai, Japan; 2Kisatosu University, Sagamihara, Japan

INTRODUCTION: IDH gene mutation was frequently found in anaplastic gliomas. Although IDH gene mutation has been reported to be a favorable prognostic factor, anaplastic tumors with IDH gene mutations sometimes recur as secondary glioblastoma. In this study, we investigated the role of
ST-032. PHENYTOIN REDUCES 5-ALA MEDIATED FLUORESCENCE IN GLOIOBLASTOMA CELLS
Christopher Steele1, Johnathan Lawrence1,3, Richard Rowin1, and Robert Wimm1,2; 1Northern Michigan University, Marquette, MI, USA; 2Marquette General Hospital, Marquette, MI, USA; 3Upper Michigan Brain Tumor Center, Marquette, MI, USA

Glioblastoma multiforme (GBM) is a devastating form of cancer, and essentially all GBM tumors recur causing mortality. A new surgical technique, fluorescence-guided resection of GBM using 5-aminolevulinic acid (5-ala), improves the extent of resection and positively impacts the length and quality of patient survival. The fluorescence achieved in neoplastic tissue depends directly on the accumulation of porphyrins derived from the metabolism of the 5-ala prodrug within the cancer cell. However, 5-ala induced fluorescence has been reported to be inconsistent. In an effort to determine the cause of the inconsistent fluorescence, the authors investigated the effect of medications commonly prescribed to brain tumor patients on 5-ala induced fluorescence. A model was developed to quantify intracellular porphyrin accumulation using a U87MG GBM cell line constitutively expressing yellow fluorescent protein (YFP-U87). 5-ala mediated fluorescence within the cells was standardized to cell number via the fluorescence emission spectra ratio of porphyrin (405 nm) to YFP (525 nm). 5-ala induced accumulation of porphyrins was measured after treating YFP-U87 cells with phenytoin, dexamethasone, or desipramine for 3 days. After 6 hours incubation with 5-ala, no significant difference in porphyrin accumulation was observed in cells treated with dexamethasone or desipramine. Phenytoin, however, significantly reduced the accumulation of fluorescent porphyrins within the YFP-U87 cell line by nearly 30% compared to the control. To optimize fluorescence during surgery and improve patient survival these results suggest that further investigations are warranted to determine the effects of commonly administered medications on 5-ala fluorescence-guided resection of GBM.

ST-033. MALE GENDER IS A RISK FACTOR FOR THE CLINICAL COURSE OF SKULL-BASE CHORDOMAS
Walter Rachinger1, Matthias Simon1, Stephan Dutzmann2, Gunther Feilj, Natalia Kremenevskaya1, Niklas Thom1, and Jörg-Christian Tonn1; 1Department of Neurosurgery, Munich, Germany; 2Department of Neurosurgery, Erlangen, Germany

OBJECTIVE: Chordomas of the skull base are rare, locally invasive and have a poor prognosis. Recently, the expression ratio of the transmembrane cell adhesion proteins N-cadherin and E-cadherin has been suggested to provide additional prognostic information. Patients who were deemed of this retrospective multicentric confirmatory study was to evaluate prognostic factors including expression of N- and E-cadherins in patients initially treated with microsurgical tumor resection. METHODS: 47 patients (21 women, 26 men, mean age 49 years) treated in five academic centers were included. Histology was centrally reviewed, as well as N- and E-cadherin-expression by immuno-histochemistry. Prognostic factors were obtained from multivariate regression models. For survival analysis the Kaplan-Meier method was used. RESULTS: The median follow-up period was 5.2 years. Gross total resection, subtotal resection and extended biopsy were done in 14.9%, 80.9%, and 4.2%, respectively.

Adjuvant radiotherapy (including proton beam irradiation) was applied in 63.8% of the patients. Median progression free survival was 7.3 years. Multivariate analysis identified male gender as an independent risk factor for tumor progression (p = 0.04) and death (p = 0.03), despite the fact that radical resection was achieved more often in males (p = 0.036). Neither expression rates of E-cadherin and N-cadherin nor their ratio did gain prognostic influence. None of the other patient-, tumor- or treatment related prognostic factors (age, duration of symptoms, Karnofsky score, extent of resection, adjuvant radiotherapy) proved to be of prognostic relevance in the multivariate model. CONCLUSION: In skull base chordomas, male patients bear a significantly higher risk of recurrency and death. Expression of E- and N-cadherin has no prognostic significance. These data might help to identify high risk patients in whom more aggressive adjuvant therapy or at least a closer follow-up schedule is warranted. Moreover, further studies are needed to elucidate the potential mechanism of gender disparity with regard to tumor progression and prognosis.

ST-034. PHOTODYNAMIC THERAPY OF BRAIN TUMORS
Harry Whelan, Mike Kelly, Sachin Jogel, Bruce Kaufmann, Andy Foy, Sean Lew, and Brendan Quirk; Medical College of Wisconsin, Milwaukee, WI, USA

We conducted a human brain tumor PDT study that evaluated the toxicity of PDT based on both light-emitting diode (LED) and laser technology in selected patients with recurrent/progressive brain tumors. Two patients displayed neurotoxicity, one after laser treatment using an intrastitial fiber directly inserted into the tumor, one with the laser-balloon adapter combination. Escalating doses of Photofrin® were tolerated to the maximum dose of 2.0 mg/kg. Light dose was 100 J/cm2. PDT in the posterior fossa or near eloquent brain was tolerated using the LED or laser-balloon adapter. All patients had tumor responses as documented by MRI and the mean time to tumor progression after PDT was 67 weeks. Eight were pediatric patients, all of whom received Photofrin®, who exhibited relapse-free survival times ranging from 8 weeks to 13 years. None showed neurotoxicity. Of the 20 patients, four had tumors in the posterior fossa area, with one developing a significant neurological deficit. This patient was one of the two using interstitial fiber illumination. 111In-Photofrin® was determined using external imaging and quantification with a gamma camera. 99mTc-DTPA was used as a control for nonspecific uptake. Specific tumor uptake of the 111In-Photofrin® occurred well beyond that resulting from blood-brain barrier breakdown. A phase 1 study is being performed on pediatric patients with supratentorial primary brain tumors who undergo neurosurgery at the Children’s Hospital of Wisconsin in Milwaukee. A minimum of 12 study subjects will be used with four different photofrin dose levels: 0.5 mg/kg, 1.3 mg/kg, 2.0 mg/kg, and 3.0 mg/kg. Phototoxicity of Photofrin® is controlled by the total light dose delivered over the treatment time. PDT lasers are equipped with a calibration unit to calibrate the fibers and yield the required power density output (mW) necessary to deliver a light dose of 240 J/cm2 + 2.
independently associated with decreased survival \( p < 0.001 \), along with greater age \( p = 0.003 \) and lower pre-operative Karnofsky performance status (KPS) \( p < 0.001 \). Larger volume residual tumors had higher rates of subsequent regrowth \( p = 0.003 \), and a higher regrowth rate in turn independently associated with decreased survival \( p < 0.001 \).

CONCLUSIONS: The median survival of patients re-operated for recurrent GBM compares favorably to historical controls. Re-operation should be considered in all patients who meet favorable pre-operative clinical and radiographic criteria. For patients undergoing re-operation, the surgical goal should be to leave a minimal amount of residual tumor tissue in order to slow tumor regrowth and maximize survival benefit.