

MR Monitored Brain Tumor Resection: Resection Completeness and Preliminary Outcomes Analysis

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Introduction:

Neurosurgical impression of tumor resection completeness often differs from post-surgical MR assessment. The advent of Intraoperative MR (iMR) provides the opportunity to address this dichotomy prior to surgical completion. The role of resection completeness on the long-term prognosis for patients, however, has yet to be well established. This study investigates the challenges of intraoperative image interpretation and presents preliminary outcomes analysis for individuals who underwent MR monitored brain tumor resection.

Materials and Methods:

MR System

The MR system is based on a short-bore, high field MR system (Philips ACS-NT) that is equipped with high end imaging gradients (23 mT/m, 105 mT/m/ms). Scan selection was tailored to the targeted lesion and included T₁ and T₂-weighted spin echoes, FLAIR, HASTE, Inversion Recovery and MP-RAGE data. Scan times ranged from 15s to 4 min depending on the type of contrast and image quality that was desired. Functional magnetic resonance imaging (fMRI) was used in several cases to identify eloquent cortices.

Images were acquired pre, intra and postoperatively and immediately interpreted. Tissue excised as a result of intraoperative MR findings was sent for a separate pathology report.

Patients

Thirty patients underwent MR monitored tumor resection between May, 1997 and September 1998. Average patient age was 35 years and ranged from 14 months to 70 years. Tumor histologies included 11 glioblastomas multiforme (GBM), 7 astrocytoma's, 3 meningioma's, 2 ganglioglioma's, 2 brain metastases, 1 oligodendroglioma, 1 anaplastic astrocytoma, 1 craniopharyngioma, 1 medulloblastoma and 1 teratoid tumor.

Results:

Intraoperative Imaging

Low grade lesions were well delineated on T₂-weighted scans throughout surgical interventions, although evidence of tumor infiltration beyond the T₂ boundary was detected in one astrocytoma. Enhancing lesions were more difficult to interpret as previously administered contrast accumulated in the resection cavity and permeated into the tissue surrounding the lesion. Additionally, acutely enhancing tissue at the resection cavity boundary was not found to be specific to residual tumor.

Resection Completeness

Resection completeness was assessed for all tumors. A resection was considered to be radiographically complete provided the full pre-operative imprint was removed during surgery. Enhancing lesions exhibiting only a thin rim of suspect tissue were classified as radiographically complete if this pattern was distinct from the pre-operative enhancement. 24/30 cases (80%) were classified as

radiographically complete based on the final intraoperative images. The reasons for incomplete resection included excessive brain swelling, infiltration of eloquent cortex and excessive intraoperative bleeding.

Recurrence/Progression

Of the 30 cases, 11 (37%) have recurred or progressed. Only one of these cases (GBM) underwent less than a radiographically complete resection. The recurrent/progressive cases included 8 GBM's, the anaplastic astrocytoma, the craniopharyngioma and the medulloblastoma. Five of these patients have gone on to die. The average time to recurrence was 6.5 months for GBM, 11 months for the anaplastic astrocytoma, 6.5 months for the craniopharyngioma and 2 months for the medulloblastoma. The 19 (63%) cases demonstrating no disease progression or recurrence have been followed for an average of 5.7 months. This includes an average follow-up period of: astrocytoma, 8.2 months (n=7); GBM, 3 months (n=3); meningioma, 5.8 months (n=3); ganglioglioma, 5.5 months (n=2); lung mets, 2.75 months (n=2); oligo, 5.5 months; and teratoid, 3 months. Five of these cases underwent incomplete resection but either responded well to post-surgical chemo (oligo, teratoid) or radiation therapy (1 astrocytoma), or were surgical procedures to alleviate epileptic seizures (ganglioglioma, astrocytoma).

15/30 tumor resections were initial surgeries performed on primary brain lesions and none of these patients have, to date, progressed or recurred (av. follow-up= 6.6 months). This is in contrast to the remaining 15 cases which were repeat surgeries of recurrent or progressive disease. Eleven of these cases have already recurred or progressed.

Complications

The incidence of complications has been low and is comparable to a conventional operating room. The 30 tumor resections have resulted in one infection (*Propionibacterium acnes*) and a stroke during a hippocampal resection. The overall infection rate for the suite spanning over 125 neurosurgical procedures is less than 2%. There have been no untoward events experienced related to MR-compatible instrumentation or patient monitoring.

Conclusions:

MR monitoring of brain tumor resection progress is practical on a short-bore, high field interventional MR system. Resection progress is well demonstrated intraoperatively and a complete radiographic resection was achieved in a high percentage of cases. Enhancing lesions proved the most challenging to interpret intraoperatively and acute enhancement at the resection cavity boundary was not found to be specific for residual tumor. Preliminary outcome analysis supports the hypothesis that complete resection of low grade gliomas will improve clinical outcome. No adverse incidents relating to the MR system or the use of MR compatible equipment were noted and sterility was not compromised in this environment.