Use of Topical Landmarks for Percutaneous Projection of Intracranial Tumors for Neurosurgical Oncology

INTRODUCTION

Cortical damage infliction during intracranial cortical and subcortical tumor surgery can lead to irreversible function loss. These motor and sensory deficits have deleterious effects on the patients’ quality of life. Therefore, keeping collateral cortical damage at minimum during intracranial tumor ablation is of vital importance. The neocortical surface is formed by a complex interlace of sulci and gyri that not only house critical neural networks, but are also crucial for surgical navigation as well. Using MRI (Magnetic Resonance Imaging), cortical landmarks such as sulci, gyri and vessels can be defined, along with the tumor and its neighboring structures (1,28). Cortical and vascular structures surrounding the tumor, which are best visualized, after the administration of the contrast medium, are useful for planning the surgery as well (11,15,16,29). For example, a cortical vein is very useful for pinpointing the lesion while avoiding venous bleeding. The choice of craniotomy significantly influences the incidence of postoperative neurological deficits (9). Many imaging modalities including functional MRI have been developed.
in order to define cerebral cortical anatomy in intracranial
tumors with cortical involvement (12,23). Recent studies have
demonstrated that functional MRI more effectively visualizes
focal brain neoplasias and their relations to the sensorial and
motor cortex (9).

A number of MRI-utilizing modalities have been developed
to safely navigate through the cortex to access cortical and
subcortical tumors. In this paper, we are introducing a simple,
inexpensive and highly effective method for planning skin
incision, craniotomy flap and excision margins for cortical and
subcortical tumors using the MRI-assisted tumor projection
method.

**PATIENTS/MATERIAL and METHODS**

Fifty-three patients with cortical and subcortical tumors
treated in our clinic between years 2006 and 2010 were
included in our study. The tumors were located in the
parietal lobe in 43 and frontal lobe in 10 of the patients.
The pathological studies revealed that they consisted of
meningiomas (24), brain metastases (26), cavernomas (1) and
primary brain tumors (17). These patients were divided into
two categories depending on the cortical and subcortical
localization of the tumor (39.6% and 60.4%, respectively). The
surgical outcomes of the patients were graded according to
the precision of tumor excision.

**Imaging:** A 3x3 cm area which approximately overlies the
tumor on the patients’ hair is shaved with a clipper, and one
half of a smoothly cut hazelnut is taped on the skin. After
that, the patient accompanied with a neurosurgeon is sent
to MRI and 0.1 mmol/kg contrast material is administered
(Magnevist®, 0,5mmol/mL, Schering, Germany). After the first
MRI, the localization of the hazelnut is checked and adjusted
until it is located precisely over the tumor’s projection in axial,
coronal and sagittal plains confirmed with imaging following
each adjustment. After the localization of the hazelnut is
confirmed, its underside is painted with a skin marker and
returned to its localization. Then contrast-enhanced T1-
weighted axial and coronal images are obtained (Tesla active
super-conducting magnet system, Magnetom Symphony-
Quantum, Siemens, Erlangen, Germany) (Figure 1A,B). The
hazelnut is firmly kept in place until surgery.

**Surgical Technique:** Under general anesthesia, the patients’
head is fixed with a Mayfield skull clamp. The hazelnut is
removed and the staining on the skin is checked (Figure
2). After prepping and draping, the stained impression is
projected to the bone using the Midas Rex cutting tip (Figure
3). Once the consistency of bone is felt, the skin flap is raised.
The impression made by the cutting tip is located and it is
drilled past to dura. The dura is marked with a marker past
the initial drill hole and a 4x4 cm craniotomy is made (Figure
4A,B). The marked spot on the dura is located and the cortex is
likewise marked through a small incision. The dura is then duly
incised to expose the cortex (Figures 5, 6). A cortical tumor is
directly removed after this exposure. For a subcortical tumor,
the cortical landmarks which have been visualized previously

![Figure 1: A) T1-weighted contrasted axial section MRI with
hazelnut on the skin. B) T1 weighted contrasted coronal section
MRI with hazelnut on the skin.](image)

![Figure 2: The patient’s head is fixed with Mayfield skull clamp,
the hazelnut is removed and the staining on the skin is checked.](image)
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Figure 3: After prepping and draping, the stained impression is projected to the bone using the Midas Rex cutting tip.

Figure 5: Cortical surface. The instrument tip points to the impression of the cutting tip, which the tumor lies directly underneath.

Figure 4: A) The appearance of exposed calvarial surface with the impression made by the Midas Rex cutting tip. B) After the calvarial flap has been raised, the dura is seen with the impression of the cutting tip.

Figure 6: Surface USG to confirm the tumor presence underneath the projection.

The efficacy of the method has been evaluated via a grading system. Grading in cortical tumors was done according to the projection’s accuracy in covering the boundaries of the tumor. Grading of subcortical tumors were done according to the match between the previously made projection and the cortical projection of the tumor which was perioperatively

RESULTS

are utilized and three-dimensional volume-rendered MR images are compared with real-time appearance. Cortical landmarks surrounding the tumor’s cortical projection are further confirmed with cortical ultrasonography (USG). The cortical split is then done accordingly. Thus, the exact relationship between the central sulcus and the split is known and the tumor is removed without damaging the superficial veins or inflicting redundant cortical damage. All patients undergo contrast-enhanced MRI within the first 2 postoperative days (Figure 7A,B).
established by USG. Grade 1 and 2 are considered successful. In the follow-up of our patients, the postoperative complication rate was 12.5% in the subcortical tumor category (4 patients). Within the cortical tumor group, only 1 patient developed a mild motor deficit which resolved spontaneously (4.7%) (Table I).

**DISCUSSION**

Total surgical ablation of the tumor has been considered the ultimate treatment in a brain neoplasia (5,7,14,22). However, damaging the cortical substance along the way may have catastrophic consequences. The precise tumor localization is of vital importance especially when the tumor is virtually indistinguishable from the surrounding intact tissue.

The stakes of technological developments are increasing day by day in this field. Image-guided neurosurgical techniques using navigation systems have been used in patients with brain tumors since 1980’s (27). Utilization of these developments provided more accurate access to the tumor, which was reflected in decreased morbidity, shorter hospitalization and lower cost (2,19).

Frameless image-guided navigation systems are widely used in intracranial surgery (19). Anatomic deformation of the parenchyma can effectively be demonstrated intraoperatively by integration of Computerized Tomography (CT) and MRI data to the navigation system (17). However, its cost and requirement for trained staff have limited its use (6). The use of this system also requires extensive intraoperative time (6,10).

These drawbacks called for a simple method with more modest requirements. Subcortical brain tumors cannot be distinguished from the brain’s surface even after considerable growth in size (8). Intraoperative USG and MRI can pinpoint these lesions following cortical exposure but require time under general anesthesia, are costly and their accuracies are compromised due to brain shift (20,26). Real time navigation systems such as intraoperative MRI and three-dimensional USG are very effective diagnostic tools but require special and expensive hardware (13).

MRI-based corticotopography developed by Esposito et al. has been successfully used for intraoperative localization of subcortical brain tumors. However, it is more complex and expensive than our method and it depends on external landmarks such as craniometric points, mastoid bone and the external ear for bone flap planning (8).

Surgical planning is done according to the cortical landmarks.

**Table I:** Grading the Success of the Projections in the Operated Patients. **Grade 1:** Projection Exactly Matches the Actual Tumor. **Grade 2:** The Margin of Error Between the Projection and the Tumor is Less than 5 mm. **Grade 3:** The Margin of Error Between the Projection and the Tumor is Greater than 5 mm

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<th></th>
<th>Cortical Tumor (n=21)</th>
<th>Subcortical Tumor (n=32)</th>
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<tr>
<td>Grade 1</td>
<td>16 (76,2 %)</td>
<td>21 (65,6 %)</td>
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<td>Grade 2</td>
<td>4 (19 %)</td>
<td>8 (25 %)</td>
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<tr>
<td>Grade 3</td>
<td>1 (4,7 %)</td>
<td>3 (9,3 %)</td>
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and thus preserves our orientation in our system. The system uses the sulci, gyri and vessels in the vicinity of the tumor and thus provides the surgeon extensive comfort while accessing the cortical tumors. While this method can likewise be used for subcortical tumors, an intraoperative USG is recommended for confirming the location of the tumor before commencing the cortical split. The system therefore provides quick access to the tumor with minimal cortical split.

Three-Dimensional Volume Rendering for Tissues (3D VRT) has been utilized for surgical planning in our clinic since 2002. We have achieved 80% correlation with 3D VRT images and surgical observation. Easier skin incision planning and smaller bone flap requirement have been achieved via the projection method. This method provides smaller chances of encountering unpleasant surprises in the postoperative period along with better orientation for the surgeon. The rate of postoperative deficit following subcortical tumor ablation in our series has been 12.5%, which is comparable with the 13.27.5% postoperative deficit rates reported in the literature (3,4,21,25). The only postoperative complication encountered in cortical tumor ablation in our series has been a transient motor deficit which spontaneously resolved.

CONCLUSION

We believe that we are introducing a cost effective, convenient and reliable method for swiftly and accurately accessing cortical and subcortical tumors.

REFERENCES


