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

Nöroonkolojik Cerrahide İntrakranial Tümörlerin Topikal İşaretler Kullanılarak Perkütan Projeksiyonu

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ABSTRACT

AIM: The objective of this study was to introduce a surgical navigation method which provides a safe, quick and effective access to cortical and subcortical tumors, along with a review of other methods in use for this purpose.

MATERIAL and METHODS: 53 patients have been operated using this technique. The area overlying the tumor is shaved and one half of a smoothly cut hazelnut is taped on the skin. The precise localization of the hazelnut is confirmed with MRI and then stained. After general anesthesia, the stained impression is projected firstly to the bone, dura and then cortex respectively by the Midas Rex cutting tip. Cortical landmarks surrounding the tumor's cortical projection are further confirmed with ultrasonography.

RESULTS: After removal, cortical and subcortical tumors were separately graded for efficiency. Grade 1 and 2 were accepted as precise access. Our method accordingly yielded 95.2% and 90.6% success rates for cortical and subcortical tumors respectively.

CONCLUSION: Considering the method's success rate along with its inexpensiveness and modest technical requirements, it is believed that this method can be of widespread use.

KEYWORDS: Cortical landmarks, Subcortical tumor, Cortical tumor, Tumor localization, Surgical navigation

ÖZ

AMAÇ: Bu çalışmanın amacı, kullanımda olan diğer metodları da gözden geçirerek, topikal işaretler yardımıyla kortikal ve subkortikal yerleşimli tümörlerde etkili, güvenli ve hızlı bir cerrahi yöntemi sunmaktır.

YÖNTEM ve GEREÇLER: 53 hasta bu teknik kullanılarak opere edildi. Tümörün izdüşümündeki saçlı deri traş edildikten sonra düzgün şekilde yarısı kesilmiş fındık cilt üzerine yapıştırıldı. Fındığın tümör izdüşümündeki lokalizasyonu doğrulandıktan sonra alan işaretlendi. Genel anestezi altında işaretlenmiş alanın izdüşümü alınarak sırasıyla kemik ve dura, kortekse kadar Midas rex kesici uç yardımıyla işaretlendi. Tümör ve onu çevreleyen kortikal yapılar ultrasonografi yardımıyla görüldü ve doğrulandı.

BULGULAR: Tümör çıkartıldıktan sonra etkinlik açısından derecelendirme yapıldı. Buna göre grade 1 ve grade 2 lokalizasyon açısından kesin doğru giriş noktası olarak kabul edildi. Bizim metodumuzun subkortikal tümörlerde %90,6 ve kortikal tümörlerde %95,2 oranında giriş noktası açısından etkin olduğu saptandı.

SONUÇ: Bu yöntem ucuzluğu, basit ve kolay şekilde uygulanabilirliği nedeniyle geniş bir kullanım alanı olabilecek bir teknik gibi gözükmektedir.

ANAHTAR SÖZCÜKLER: Kortikal landmarklar, Subkortikal tümör, Kortikal tümör, Tümör lokalizasyonu, Cerrahi navigasyon

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

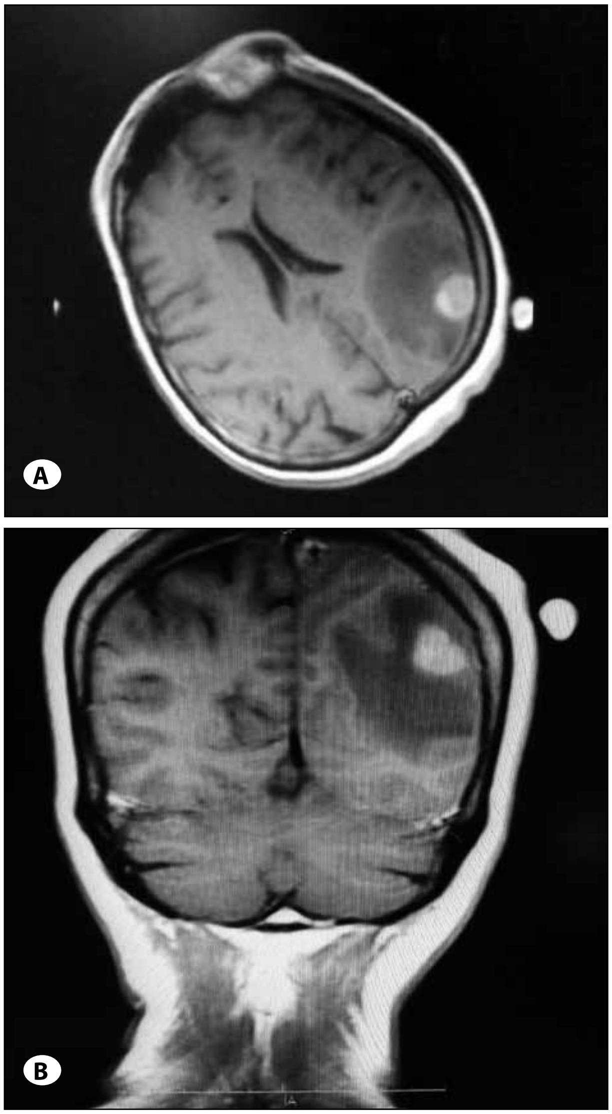

Figure 1: A) T1-weighted contrasted axial section MRI with hazelnut on the skin. **B)** T1 weighted contrasted coronal section MRI with hazelnut on the skin.

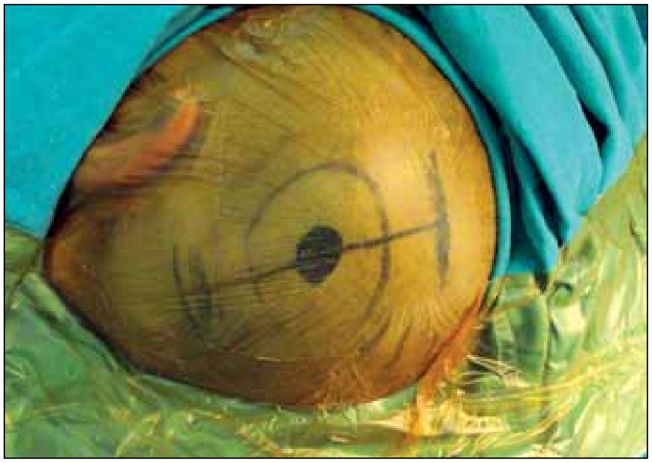

Figure 2: The patient's head is fixed with Mayfield skull clamp, the hazelnut is removed and the staining on the skin is checked.

Figure 3: After prepping and draping, the stained impression is projected to the bone using the Midas Rex cutting tip.

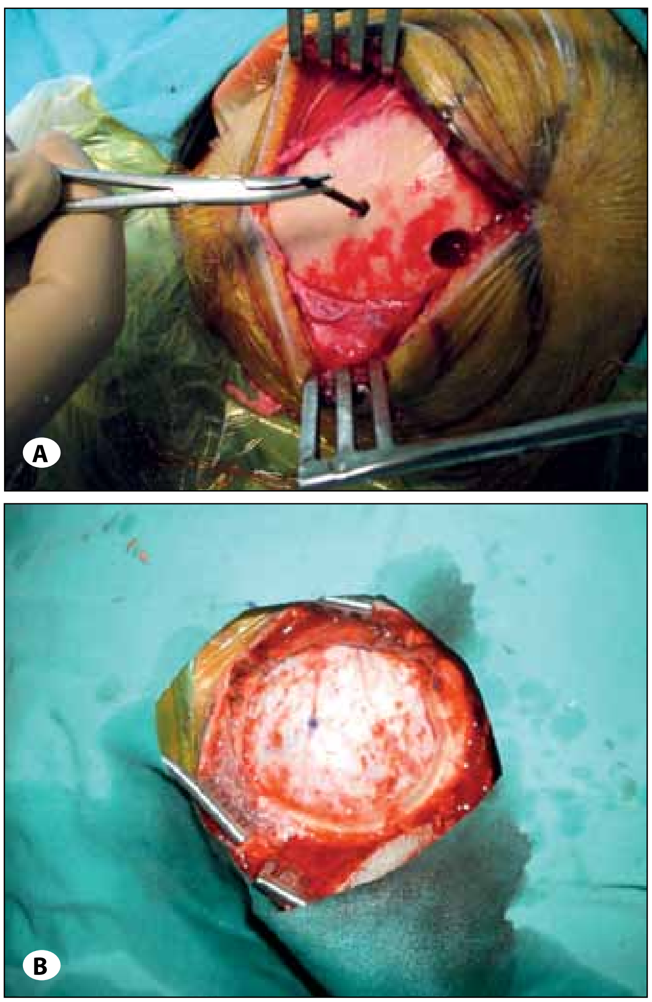

Figure 4: A) The appearance of exposed calvarial surface with the impression made by the Midas Rex cutting tip. **B)** After the calvarial flap has been raised, the dura is seen with the impression of the cutting tip.

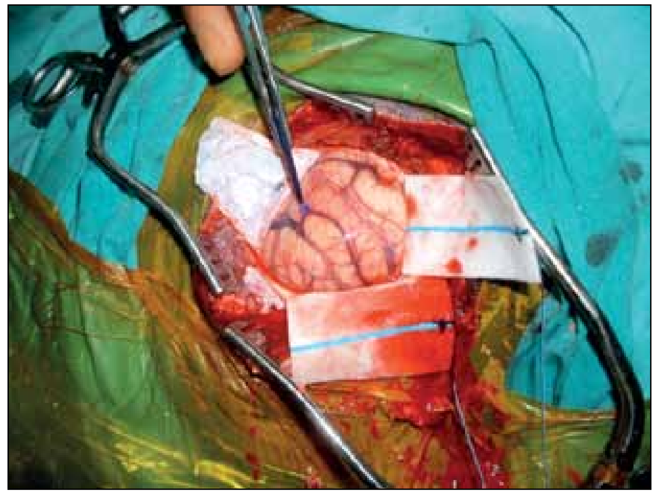

Figure 5: Cortical surface. The instrument tip points to the impression of the cutting tip, which the tumor lies directly underneath.

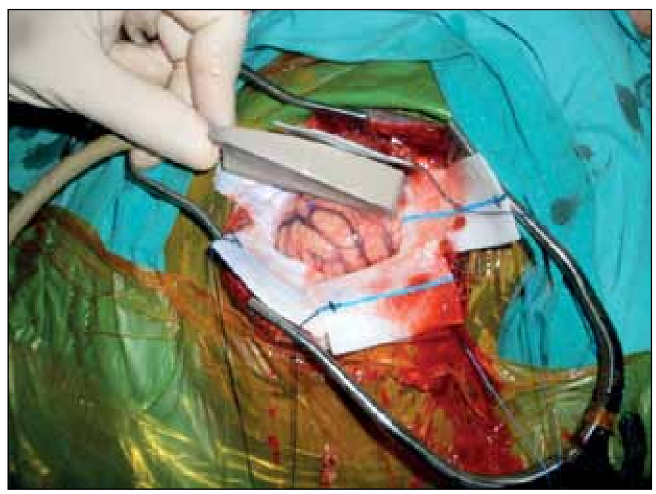

Figure 6: Surface USG to confirm the tumor presence underneath the projection.

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).

RESULTS

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

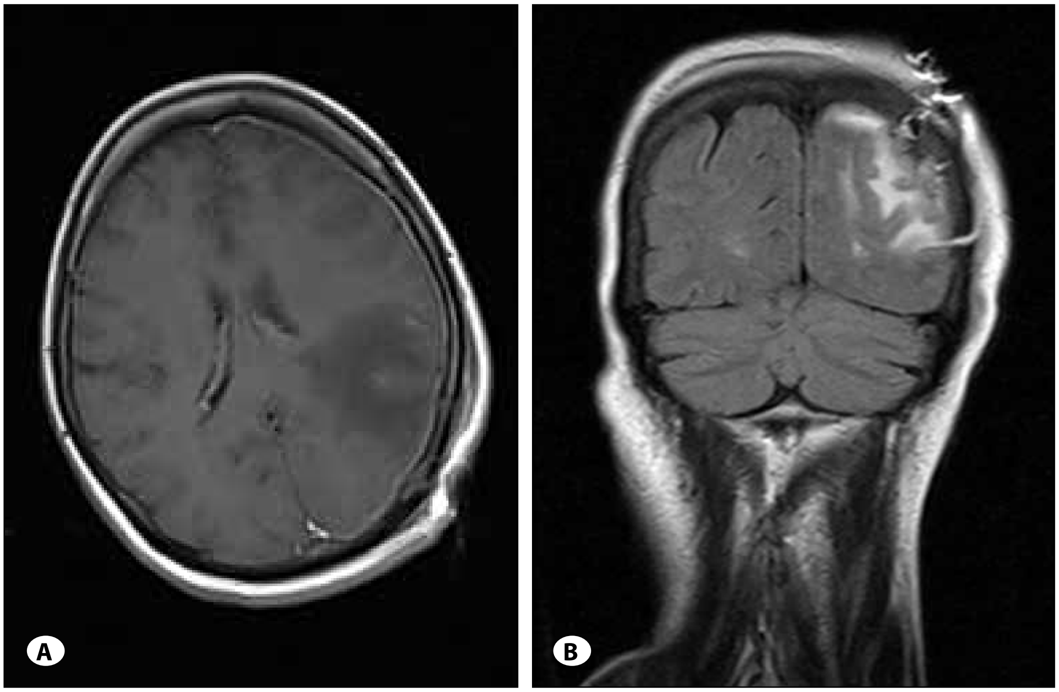

Figure 7:
A) Postoperative T1-weighted contrasted axial section MRI
B) Postoperative T1-weighted contrasted coronal section MRI.

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

	Cortical Tumor (n=21)	Subcortical Tumor (n=32)
Grade 1	16 (76,2 %)	21 (65,6 %)
Grade 2	4 (19 %)	8 (25 %)
Grade 3	1 (4,7 %)	3 (9,3 %)

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.

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