

Endoscopic Biopsy for Lesions Located in the Parenchyma of the Brain: Preoperative Planning Based on Stereotactic Methods

—Technical Note—

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Abstract

Endoscope biopsy guided navigation for intra-parenchymal lesions is safe and effective, but determination of the entry point and trajectory of the endoscopic biopsy is less clear. We describe preoperative planning based on stereotactic methods, and achieving the plan using several techniques. The preoperative planning was based on stereotactic methods such as determining target, entry point, and trajectory. A transparent sheath was advanced under guidance of the navigation system and specimens collected under visual endoscopic monitoring. After collecting specimens, intraoperative magnetic resonance imaging was performed for confirming accurate sampling. Correct specimens were obtained in 6 cases as confirmed by intraoperative magnetic resonance imaging. The histological diagnoses were diffuse large B-cell type malignant lymphoma (n = 3), astrocytoma (n = 1), glioblastoma (n = 1), and inflammatory changes without neoplastic cells (n = 1). No postoperative intracranial hemorrhage or other operative complications occurred. Preoperative planning based on stereotactic methods and procedures guided by navigation systems can achieve endoscopic biopsy for intraparenchymal lesions safely and accurately.

Key words: endoscopic biopsy, intraoperative magnetic resonance imaging, navigation, preoperative planning, stereotactic method

Introduction

Stereotactic biopsy is widely used for the histological diagnosis of intracranial lesions, but postoperative symptomatic hemorrhage complications have been reported in 1.1–4.35% of procedures.^{2,3,6)} In particular, hemorrhage is an uncommon but serious complication of stereotactic brain biopsy. Recently, the safety and effectiveness of biopsy for lesions located in the parenchyma of the brain using the rigid endoscope and guided navigation have been evaluated.^{1,4)} The advantages of endoscopic biopsy compared with stereotactic biopsy are that the operator can perform the whole procedure under direct visual monitoring, can stop bleeding from the lesion, and obtain adequate specimens.⁷⁾ Compared with

small craniotomy biopsy, endoscopic biopsy is less invasive. Several reports have described the procedures of endoscopic biopsy for intra-parenchymal lesions, but few reports have discussed the strategy to determine the entry point and trajectory of the endoscope. Here we describe preoperative planning based on stereotactic methods, and achieving the plan using several techniques.

Materials and Methods

Surgical planning was based on multiple sequences of magnetic resonance (MR) imaging taken 2 or 3 days before surgery. The target lesion and important anatomical structures were coded as colored objects. Image fusion was used to integrate and display areas of increased metabolism detected by fluorine-18 fluoro-2-deoxyglucose positron emission tomography ([¹⁸F]FDG PET). Diffusion tensor imaging was

performed to visualize the major white matter tracts such as the pyramidal tract. The preoperative planning was performed using iPlan Stereotaxy (BrainLAB AG, Heimsteten, Germany). The biopsy target was set at the middle of the enhanced lesions on MR images and high accumulation on [¹⁸F]FDG PET. The trajectory and the entry point were initially planned to achieve the most direct route from the brain surface to the target. Then we carefully checked the anatomical location of the entry point and the trajectory using the Probe View mode of iPlan Stereotaxy. If the planned route passed through important anatomical structures, the sulcus or ventricle, the entry point and the trajectory were moved to allow a safer route.

We used the following surgical instruments; a rigid 0 degree endoscope with 5-mm diameter (Olympus Medical Systems, Tokyo), a transparent sheath (Neuroport; Olympus Medical Systems), and a Leksell stereotactic biopsy needle with 2.5-mm diameter (Elekta, Stockholm, Sweden). Before surgery, the rigid endoscope and the Leksell stereotactic biopsy needle were mounted on a navigation system (BrainSUITE; Brain LAB AG) (Fig. 1A, B).

The surgical procedure was performed with the patient under general anesthesia with 5-point head fixation. Based on information from the navigation system, a single linear 5-cm skin incision was made at the entry site. One burr hole was drilled and slightly widened. The rigid endoscope was inserted into the inner tube of the transparent sheath. The rigid endoscope was shorter than the sheath by 10

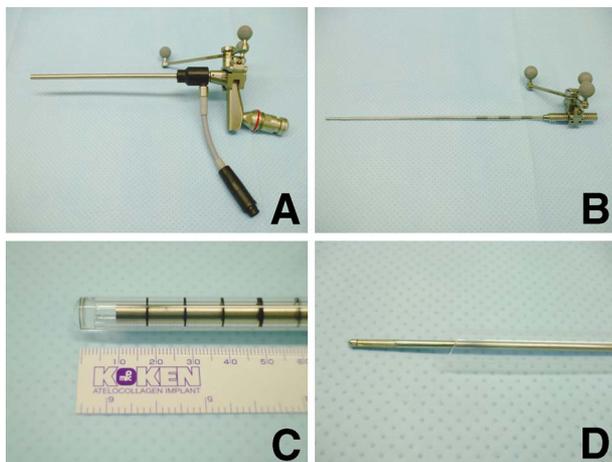


Fig. 1 Rigid endoscope and Leksell stereotactic biopsy needle mounted on a navigation system (A, B). The rigid endoscope was shorter by 10 mm than the tip of the sheath (C). The Leksell stereotactic biopsy needle is longer than the outer tube of the sheath, to confirm the location over the sheath tip (D).

mm (Fig. 1C), so we could confirm the theoretical location of the sheath tip on the navigation image by the configuration 10 mm forward of the rigid endoscope. Then we advanced the sheath along the preoperative planning trajectory guided by the navigation system. At that time, we could also check the borders between normal brain tissues and target lesion through the transparent sheath on the endoscopic monitor. We checked the location of the sheath tip using the Leksell stereotactic biopsy needle mounted on the navigation system. The operator sampled the tissue with a straight forceps under direct monitoring with the endoscope, and used the aspirator tip as a monopolar coagulator to control bleeding. The Leksell stereotactic biopsy needle was longer than the outer tube of the sheath, so we could also check the exact location of the biopsy points over the sheath tip (Fig. 1D). After collecting adequate specimens, intraoperative MR imaging was performed to confirm that the specimens were collected from the target.

Results

We performed endoscopic biopsy guided by navigation for lesions located in the parenchyma of the brain in six patients, 3 males and 3 females aged 38–71 years (mean 54.7 ± 14.6 years) between May

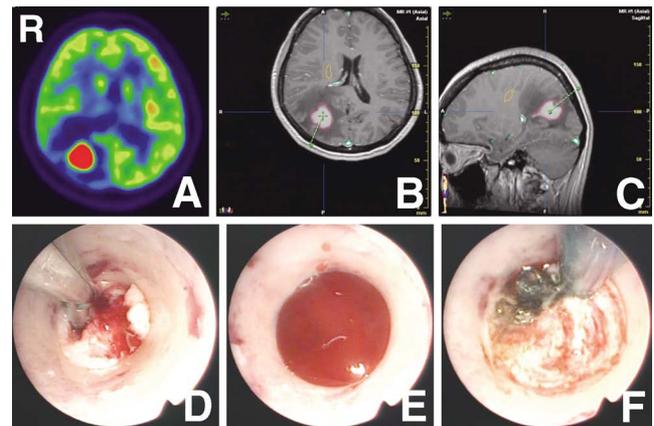


Fig. 2 Illustrative Case 1. A: Fluorine-18 fluoro-2-deoxyglucose positron emission tomography scan showing high accumulation in the right parietal lesion. B, C: Preoperative navigation planning images showing the lesion (pink) and the pyramidal tract (yellow) coded as colored objects. The target was set at the middle of the lesion, and the trajectory was planned to provide the most direct route from the brain surface to the target (green line). D–F: Intraoperative endoscopic views. The specimens were collected from the lesion with straight forceps (D), bleeding from the lesion (E), and controlled the bleeding by monopolar coagulations (F).

Table 1 Summary of cases

Case No.	Age (yrs)	Sex	Location	Histological diagnosis	Accurate sampling of the lesion	Necessary hemostasis procedures under endoscopic monitoring	Postoperative intracranial hemorrhage
1	41	F	parietal	diffuse B cell lymphoma	yes	yes	no
2	71	M	temporal	inflammatory cell infiltrate	yes	yes	no
3	68	M	frontal	diffuse B cell lymphoma	yes	yes	no
4	46	F	parietal	glioblastoma	yes	yes	no
5	64	M	frontal	diffuse B cell lymphoma	yes	yes	no
6	38	F	frontal	astrocytoma (grade 2)	yes	yes	no

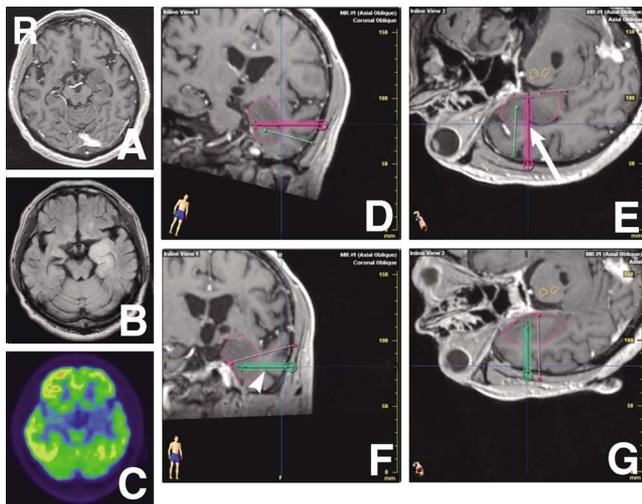


Fig. 3 Illustrative Case 2. A, B: Magnetic resonance images showing the left medial temporal lesion as low intensity on the T₁-weighted image with gadolinium (A), and hyperintensity on the fluid-attenuated inversion recovery image (B). C: Fluorine-18 fluoro-2-deoxyglucose positron emission tomography scan showing low accumulation in the lesion. D, E: Preoperative planning images showing the entry point was set at the left middle temporal gyrus, and the trajectory was the most direct route to the target (pink line). However, the trajectory passed through the lateral ventricle (arrow), so the plan was rejected. F, G: Preoperative planning images showing the target moved anteriorly and the entry point moved to the lower part of the middle temporal gyrus. This trajectory was confirmed to not pass through the lateral ventricle and the inferior temporal sulcus (arrowhead). These trajectories were drawn as the same thickness as the outer sheath with 10-mm diameter.

2006 and June 2011 (Table 1). In Cases 4 and 6, the lesions were located in eloquent areas and glioma was suspected based on the preoperative MR images. Appearances of new neurological deficits were assumed if radical tumor removal was performed, so the two patients were selected for diagnostic surgery

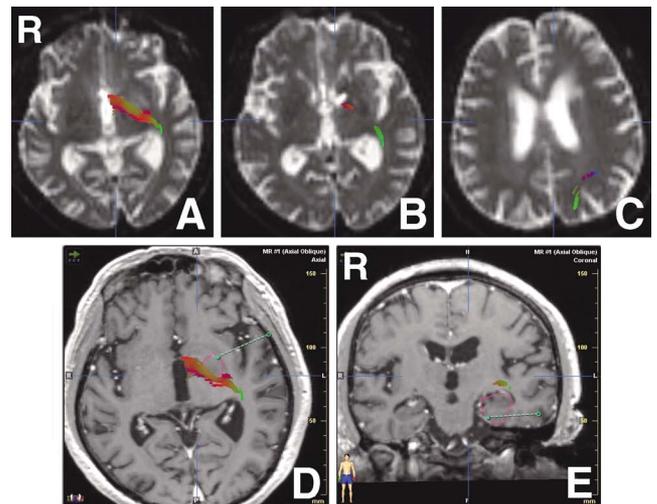


Fig. 4 Illustrative Case 2. A-C: Axial T₂-weighted magnetic resonance images with superimposed color coding of fiber tracks of the left optic radiation and Meyer's loop. Fiber directions of the right-left, anterior-posterior, and superior-inferior orientations were coded in red, green, and blue, respectively. D, E: The adopted trajectory was confirmed to not pass through the optic radiation and Meyer's loop.

not radical tumor removal. The predominant lesions were located as follows: the frontal lobe (n = 3), parietal lobe (n = 2), and temporal lobe (n = 1). Specimens from the preoperative target were obtained in all cases as confirmed by intraoperative MR imaging and postoperative computed tomography. The histological diagnoses were diffuse large B-cell type malignant lymphoma (n = 3), astrocytoma (grade 2) (n = 1), glioblastoma (n = 1), and inflammatory changes without neoplastic cells (n = 1). Bleeding from the lesion during biopsy was encountered in all cases, and hemostasis was accomplished under endoscopic monitoring. No postoperative intracranial hemorrhage or other operative complications occurred.

Illustrative Case 1: A 41-year-old woman presented with headache. MR imaging showed a mass lesion located in the right parietal lobe. [^{18}F]FDG PET demonstrated very high accumulation in the mass lesion (Fig. 2A). The lesion was suspected to be malignant lymphoma, so biopsy was scheduled. Preoperative planning of the trajectory and the entry point followed the most direct route to the target (Fig. 2B, C). We advanced the sheath along the planned route with the navigation system and collected specimens from the target. We encountered bleeding from the biopsy points, but complete hemostasis was achieved by monopolar coagulation under endoscopic monitoring (Fig. 2D–E). The histological diagnosis was diffuse large B-cell type malignant lymphoma.

Illustrative Case 2: A 71-year-old man was hospitalized with a first generalized convulsion. He had presented with partial seizures 3–4 times a day from 2 months before, but he had not visited a hospital. MR imaging showed left medial temporal lobe abnormalities (Fig. 3A, B). [^{18}F]FDG PET showed low accumulation in the lesion (Fig. 3C). The lesion was suspected to be inflammatory changes such as herpes encephalitis, but no diagnosis could be established despite several examinations. Then the lesion was suspected to be not inflammatory but brain tumor, because MR imaging did not show any changes for 3 months and slight swelling compared with the contralateral medial temporal lobe. His seizure attacks were well controlled by anticonvulsants.

We planned staged surgical procedures because the lesion was located in the dominant medial temporal lobe. As a first step, we selected biopsy to decide whether the lesion was brain tumor or not. As a second step, if the lesion was high grade glioma or other malignant tumor, we would select radical lesion removal. If the lesion was low grade glioma or other benign lesion, we would select conservative treatment. Initially, we planned the entry point at the anterior part of the left middle temporal gyrus to avoid injury to the superior temporal gyrus, and the trajectory was set to provide the most direct route to the target. However, the trajectory passed through the lateral ventricle (Fig. 3D, E). Next, the target was moved anteriorly and the entry point was moved to the lower part of the middle temporal gyrus. This trajectory was confirmed to not pass through the lateral ventricle, the sulcus (Fig. 3F, G), optic radiation, or Meyer's loop (Fig. 4), so we adopted this plan. The histological findings showed small hemorrhage and partial brain edema with inflammatory cell infiltration without neoplastic cells, but no final pathological diagnosis was made. He did not show

any neurological deficits or deterioration of seizure attacks after surgery. Nine months after surgery, follow-up MR imaging did not show any changes.

Discussion

Endoscopic biopsy for lesions located in the parenchyma of the brain is difficult because of the absence of landmarks, but guidance by navigation systems makes this possible. Advantages of endoscopic biopsy compared with stereotactic biopsy are direct visualization and performance of hemostasis procedures to decrease postoperative intracranial hemorrhage.⁷⁾ Stereotactic brain biopsy is safe, but postoperative hemorrhage is a serious complication.^{2,3,6)} All our cases involved moderate bleeding after obtaining sufficient specimens, but no postoperative intracranial hemorrhage occurred after coagulation procedures under endoscopic monitoring. Disadvantages of endoscopic biopsy compared with stereotactic biopsy are inferior accuracy and thickness of the transparent sheath. The transparent sheath commonly used for endoscopic biopsy has 10-mm diameter, compared with the Leksell stereotactic biopsy needle with 2.5-mm diameter. Therefore, endoscopic biopsy is more invasive than stereotactic biopsy due to the damage along the trajectory in the brain tissue. The trajectory and the entry point of the endoscopic biopsy should be carefully planned before surgery.

Our preoperative planning for endoscopic biopsy used stereotactic methods. These methods are routinely used for stereotactic surgery such as deep brain stimulation surgery. First, the target is configured, then the entry point is temporarily set on the brain surface which is considered functionally safe. Then the trajectory is checked by the “Prove View” mode to not pass through important structures. Loss of cerebrospinal fluid causes brain shift which induces discrepancies between navigation images and real structures, which may result in failure to sample the accurate target tissues.⁸⁾ Furthermore, proximity to a sulcus along the trajectory of the brain stimulation surgery is a significant risk factor for hemorrhagic and nonhemorrhagic cortical complications.⁵⁾ Therefore, the trajectory should avoid passing through the ventricle or sulcus. If the trajectory passes or grazes these structures, the entry point and the trajectory should be moved to a safer area. If the trajectory passes near these structures, more accurate planning is possible by the trajectory line configuring the same thickness of the sheath.

Endoscopic biopsy for intra parenchymal lesions is safe and effective. Preoperative planning based on

stereotactic methods and performing planning guided by navigation systems allow the biopsy to be completed safely and accurately.

Disclosure

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