Magnetic Resonance Imaging-guided Stereotactic Biopsy: A Review of 83 Cases with Outcomes

Abstract

Background: The purpose of this study was to determine the relationship between the radiological and histopathological distribution of the cerebral lesions diagnosed with stereotactic biopsy (STB) procedure and its outcomes. **Materials and Methods:** In the current study, a retrospective analysis of 83 patients that underwent the STB in our clinic from January 2011 to December 2015 was made. T1-weighted contrast-enhanced cranial magnetic resonance imaging examinations were performed on patients on whom Leksell stereotactic frame system was installed. The histopathological and the radiological data derived from the STB procedure were classified. **Results:** In terms of localization, glial tumor (56.6%) was the most common lesion in all regions, except for the multifocal lesions. Contrary to the common knowledge, lymphoma (14.4%) was found to be the most common lesion among multifocal lesions. The success of obtaining positive STB samples in the current series was 95.2% and the complication rate was 3.6%. **Conclusion:** Had a routine computed tomography scan been performed on each patient in this series, the number of clinically insignificant small intracerebral hematomas would have probably been higher. Nevertheless, the rate of the STB sampling accuracy and the complication rate were similar to those reported in the relevant literature.

Keywords: *Brain lesion, complication, histopathology, radiology, stereotactic biopsy*

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Introduction

Use of stereotaxis in neurosurgery first began in the 1950s.[1,2] Stereotactic biopsy (STB) is a common technique used to diagnose cerebral lesions. Histopathological diagnosis is of the key value for determining the treatment modalities in neuro-oncology. Although the development of cerebral imaging techniques has provided convenience in determining the nature of the tumor, these imaging techniques have not replaced the histopathological diagnosis yet. Massive excision with open surgery is the optimum method that directly affects the survival in neuro-oncology. On the other hand, the STB method is used as the first choice in the histological diagnosis of the deeply located cerebral lesions, also in multifocal tumors and lesions located in functional areas.

The STB procedure is a reliable method for diagnosing the lesions that cannot be excised through open surgery due to their depth, number, and/or location.

In this study, the data of 84 STB samples of 83 selected patients were presented.

Materials and Methods

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Institutional and/or National Research Committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study. The institutional approval of the study and publication was obtained before the study.

From January 2011 to December 2015, in our department, 83 patients were taken 84 STB procedures (one patient underwent the procedure twice) to diagnose cerebral lesions they had according to the magnetic resonance imaging (MRI) results. The demographic data revealed that, of the 83 patients included in this study, 52 were males and 31 were females with the age ranged from 10 to 83 (mean = 53.6). The STB technique was used for those patients with multiple lesions, with deeply located lesions, and with lesions which could not be removed through open surgery. Radiologically, the lesions were divided

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into three groups: (1) deeply located lesions, which were also divided into three subgroups: (i) callosal and pericallosal lesions, (ii) thalamic and basal ganglia lesions, and (iii) brain stem lesions; (2) lobar lesions, which were of dimension rendering excision difficult with open surgery, and (3) multifocal lesions.

Stereotactic biopsy technique

Leksell stereotactic frame was placed on the head of the patients, who were under local anesthesia, and the contrast-enhanced T1-weighted MR images were obtained. The section width of the images was 2 mm. For the STB procedure, the intense contrasted parts of the lesions under contrast-enhanced T1-weighted MR images were targeted. For the noncontrast enhanced lesions, the center of the hyperintense lesion on T2-weighted MR images was targeted.

While targeting the intense contrasted or noncontrasted lesions, the x, y, and z coordinates were calculated using the Cartesian system. The patients were under local anesthesia, and the biopsies were performed through the drill hole, using the Sedan needle kit. A minimum of three core biopsies was obtained from this target and its periphery for each individual case. In addition, for the brainstem lesions, the biopsy samples were obtained through transfrontal trajectory.

Results

Following the biopsy procedures, histopathological diagnoses were made. The histopathological results of the STB procedures of 83 cases were as follows: 47 gliomas, 12 lymphomas, 5 infections, 4 metastases, 3 histiocytoses, 2 biopsy-negative cases, 2 nonspecific lesions, 1 vasculitis, 1 infarct, 1 necrosis, 1 round cell malignant tumor, and 1 neuroepithelial cyst [Table 1].

Pathological examination results of callosal and pericallosal lesions

Glioma: 15, lymphoma: 4, and nonspecific lesion: 1.

Pathological examination results of thalamic and basal ganglia lesions

Glioma: 15, lymphoma: 3, abscess: 1, infarct: 1, and negative biopsy: 1 (one more STB was performed on this patient).

Pathological examination results of multifocal lesions

Lymphoma: 4, glioma: 4, metastasis: 2, encephalitis: 2, round cell malignant tumor: 1, vasculitis: 1, reactive gliosis: 1, necrosis: 1, histiocytosis: 1, demyelinating plaques: 1, nonspecific lesion: 1, and negative biopsy: 1.

Pathological examination results of lobar single lesions

Glioma: 9, lymphoma: 1, metastasis: 1, cerebritis: 1, histiocytosis: 2, and toxoplasma: 1.

Pathological examination results of brainstem lesions

Glioma: 4, neuroepithelial cyst: 1, metastatic adenocarcinoma: 1, and infarct: 1.

The radiological distribution of the lesions

According to the classification of the lesion on the basis of their radiological locations, the numbers of the lesions were as in Table 2. The number of callosal and pericallosal lesions was 20 [Table 2 and Figure 1], that of thalamic and basal ganglia located lesions was 21 [Table 2 and Figure 2], that of multifocal lesions was 20 [Table 2 and Figure 3], that of lobar lesions was 15 [Table 2 and Figure 4], and that of brainstem lesions was 7 [Table 2 and Figure 5].

For the four cases, histopathological diagnoses of the lesions could not be made: two of which had negative biopsy samples – normal brain tissue and two had nonspecific lesions. Therefore, three of these cases underwent biopsy procedure through stereotactic-guided awake craniotomy, and for the fourth case, the STB technique was applied again after the recalculation of the coordinates. As a result of these four cases, the histopathological diagnoses were clarified. Since the biopsy procedures followed for these four cases were accepted as unsuccessful practices, the success of obtaining positive STB samples was found to be 95.2% in the current series.

In the intraoperative and the postoperative period, there occurred some complications in three patients. One patient had permanent hemihypoesthesia after the procedure. Another patient had complaints of headache, nausea, and vomiting after the procedure, and on the control computed tomography (CT) scan, a deeply located intracerebral

Table 1: Histopathlogy of Stereotactic Biopsies

	Case no	Percentage
Glial tumor	47	56,6
Grade 4	24	28,9
Grade 3	13	15,6
Grade 2	8	9,6
Grade 1	2	2,4
Lymphoma	12	14,4
Infection	5	6
Metastasis	4	4,8
Histiocytosis	3	3,6
Infarct	2	2,4
Biopsy (-)	2	2,4
Nonspecific	2	2,4
Vasculitis	1	1,2
Reaktive gliosis	1	1,2
Necrosis	1	1,2
Small round cell tumor	1	1,2
Neuroepithelial cyst	1	1,2
Demyelinating plaque	1	1,2
Total	83	100

hematoma of 2 cm was observed. In third patient, acute respiratory failure occurred when the third biopsy sample was being obtained during the brainstem biopsy procedure. A full recovery of the respiratory function was observed at the moment of the procedure was halted. Thus, the complication rate was calculated as 3.6%.

Postoperative control computed tomography scan

Routine control CT scan was not performed on the patients postoperatively. However, control CT was performed on patients who had the side sign, headache, nausea, and vomiting on the neurological examination following the procedure. On the control CT scans, a deeply located cerebral hematoma of 2 cm dimension was determined in one patient; however, it did not require surgery.

Discussion

Gross-total excision, which is crucially important for survival in the case of glial tumors, is the surgical approach we prefer to use with glial tumor cases in our clinic. The extent of tumor resection in gliomas has a significant role on the survival.[3,4] In this series, STB was preferred particularly for deeply located tumors, multifocal lesions, and lobar lesions, which were of dimension rendering excision difficult with open surgery. STB was not performed on the cases, of which the lesion was localized at functional areas (motor cortex, Broca's) as the excisions were performed with craniotomy with the patient awake.

The four patients, who had had no primary diagnosis of any systemic cancer but having a cerebral mass at the first admission to our clinic, were diagnosed with cerebral metastasis, and they were referred to the medical oncology department for primary focus scans and oncological treatment.

The success of obtaining positive STB samples in the current series was 95.2%, whereas for the previous studies using the Leksell system, it was reported to be over 90%.[3,5] Of the four patients with negative biopsy and nonspecific lesions (2 negative and 2 nonspecific), the histopathological diagnoses changed with open surgical excision in three and repeated STB in one patient.

The complication rate in this series was 3.6% and the previous studies in the literature reported to have a complication rate from 2% to 5%.[5-17] Except for three patients who developed morbidity after the procedure, no major morbidity or mortality was detected. For the case who had complaints of headache, nausea, and vomiting after the procedure, the control CT scans showed a deeply located intracerebral hematoma of 2 cm. Following the biopsy procedures, no postoperative control CT scan was performed on any of the patients in this study. Had a routine CT scan been performed, the number of clinically insignificant small intracerebral hematomas would have probably been higher.

In their study, Yamada *et al.* found the mean rate of minor bleeding as 9.9% in their biopsy series, in which they performed postoperative CT scan on all patients.[16] In our study, biopsy was not performed on cases with a high probability of bleeding and for lesions rich with vascular tissue. Again, open biopsy samples were obtained from the masses that were localized close to tissues rich in vasculature, and as a result, the probability of intracerebral hematoma was reduced. When determining the entry points on the scalp and the targets, routes that were at a distant from the vascular structures in contrast-enhanced MR images were used. The biopsy samples of two pediatric patients (aged 10 and 15) with
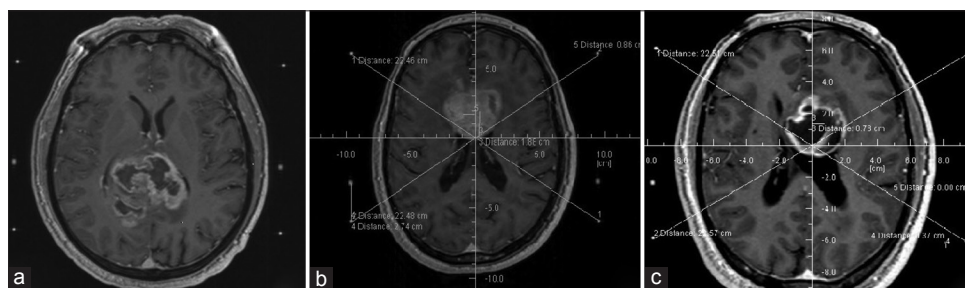

Figure 1: (a) Grade 4 glial tumor (glioblastoma multiforme), (b) lymphoma, (c) Grade 1 glial tumor (subependymal giant cell astrositoma)
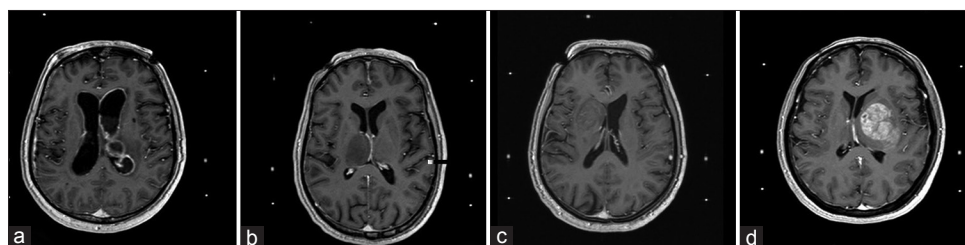

Figure 2: (a) Abscess, (b) Grade 2 glial tumor (astrocytoma), (c) infarct, (d) Grade 3 glial tumor (anaplastic astrocytoma)

Table 2: Distribution of the Cerebral Lesions on Radiological Areas		
Histopathlogy of Callosal and Pericallosal Lesions	**Case No (20)**	**%24**
GBM (grade 4)	11	
Lymphoma	4	
Anaplastic astrocytoma (grade 3)	3	
Subependymal giant cell astrositoma (grade 1)	1	
Nonspecific	1	
Histopathlogy of Thalamic and Basal Ganglia Lesions	**Case No (21)**	**%25,3**
GBM (grade 4)	4	
Anaplastic astrocytoma (grade 3)	4	
Astrocytoma (grade 2)	4	
Lymphoma	3	
Anaplastic oligodendroglioma (grade 3)	1	
Low grade glial tumor (grade 2)	1	
Gliomatosis cerebri (grade 3)	1	
Abscess	1	
Infarct	1	
Biopsy negative	1	
Histopathlogy of Multifocal Lesions	**Case No (20)**	**%24**
Lymphoma	4	
GBM (grade 4)	3	
Metastasis	2	
Encephalitis	2	
Anaplastic oligodendroglioma (grade 3)	1	
Vasculitis	1	
Small round cell tumor	1	
Reaktive gliosis	1	
Necrosis	1	
Histiocytosis	1	
Demyelinating plaque	1	
Nonspecific	1	
Biopsy negative	1	
Histopathlogy of Lobar Lesions	**Case No (15)**	**%18**
GBM (grade 4)	4	
Anaplastic astrocytoma (grade 3)	2	
Astrocytoma (grade 2)	2	
Histiocytosis	2	
Lymphoma	1	
Metastasis	1	
Cerebritis	1	
Low grade glial tumor	1	
Toxoplasmosis	1	
Histopathlogy of Brain Stem Lesions	**Case No (7)**	**%8,4**
GBM (grade 4)	2	
Anaplastic astrocytoma (grade 3)	1	
Atypical pilocytic astrocytoma (grade 2)	1	
Neuroepithelial cyst	1	
Metastasis	1	
Infarct	1	
Total	83	%100

lesions in the brainstem were obtained with the Leksell frame kit. No complications occurred following the biopsy procedures. In their pediatric STB series with 62 patients, Pattisapu *et al*.[18] reported the complication rate as 2%.

Stereotactic brainstem biopsy technique can be performed either through transfrontal or transcerebellar approach. Compared to transcerebellar approach, transfrontal approach is easier to apply since the patient is positioned supine.[19] On the other hand, though the transcerebellar

route traverses a much shorter distance, this approach, which is performed with the help of suboccipital entry point, could not be very comfortable both for the patient and the neurosurgeon as it is performed in prone or semi-sitting position. While the transfrontal approach is particularly used for the upper brainstem lesions, for the brainstem lesions laterally located, the transcerebellar approach could be the preferred route. The transfrontal approach has been more often to be reported as the preferred approach for STB, whereas the complication rates of both approaches have been reported to be similar in the relevant literature.[20]

According to the histopathological examination, 47 (56.6%) of 83 cases were diagnosed with glial tumors in this series. Eight of the glial tumors were low grade. Eight cases were those on which gross excision could not be performed owing to the location of the lesions, which posed a surgical excision risk. The applicability of STB in low-grade glial tumors is limited due to the

necessity of radical resection in those cases to achieve long survival.

Twelve (14.4%) of the lesions were diagnosed as lymphomas, and in terms of radiological distribution, lymphoma was seen everywhere except for the brainstem. Lymphomas are generally seen as a solitary lesion in the white matter, mostly in the basal ganglia and the corpus callosum.[21] In the current study, lymphomas were notable as the most common multifocal lesions according to the radiological distribution. However, the review of the literature did not yield sufficient results except for a few cases for the lymphomas located in the brainstem.[22-25] Future studies on brainstem and lymphoma if possible with more cases could add to the relevant literature and foster new approaches toward the treatment.

Conclusion

The success of obtaining positive STB samples in the current series was 95.2%. The complication rate in this series was 3.6%. Had a routine CT scan been performed on each patient in this series, the number of clinically insignificant small intracerebral hematomas would have probably been higher. Nevertheless, the accuracy of the STB sampling rate and the complication rate were similar to those reported in the relevant literature. STB is still a highly safe method in diagnosing lesions that are of dimensions that render them impossible to be excised by surgery and that are high in number or deeply located.
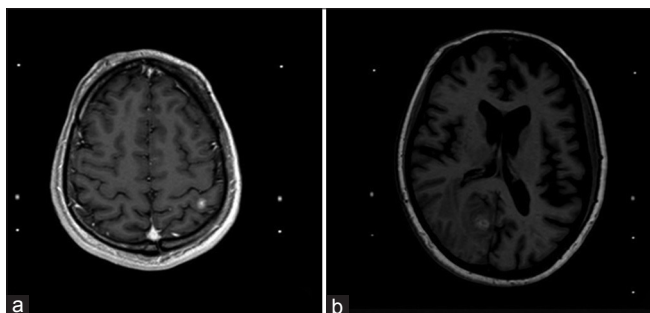

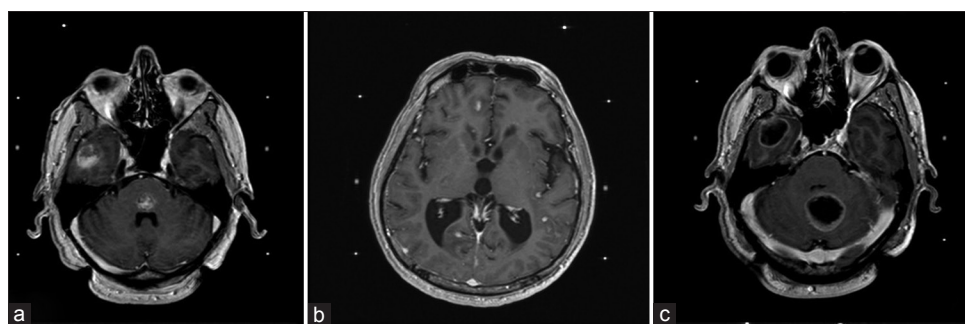Figure 3: (a) Histiocytosis and (b) cerebritis

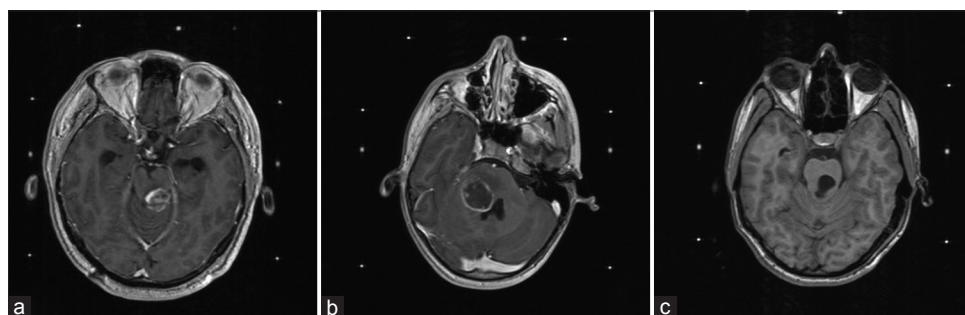Figure 4: (a) Small round cell tumor, (b) histiocytosis, (c) metastasis

Figure 5: (a) Grade 4 glial tumor (glioblastoma multiforme), (b) Grade 2 glial tumor (atypical pilocytic astrocytoma), and (c) neuroepithelial cyst

Conflicts of interest

There are no conflicts of interest.

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