Intraparenchymal brain lesion biopsy guided by a rigid endoscope and navigation system

Eiichi Ishikawa, Tetsuya Yamamoto, Masahide Matsuda, Hiroyoshi Akutsu, Alexander Zaboronok, Hidehiro Kohzuki, Shunichiro Miki, Shingo Takano, Akira Matsumura

Department of Neurosurgery, Faculty of Medicine, University of Tsukuba, Tsukuba, Japan

E-mail: *Eiichi Ishikawa - e-ishikawa@md.tsukuba.ac.jp; Tetsuya Yamamoto - yamamoto_neurosurg@md.tsukuba.ac.jp; Masahide Matsuda - m-matsuda@md.tsukuba.ac.jp; Hiroyoshi Akutsu - akutsuh@md.tsukuba.ac.jp; Alexander Zaboronok - als.neuro@gmail.com; Hidehiro Kohzuki - hidehiro1105@gmail.com; Shunichiro Miki - santreesmiki@yahoo.co.jp; Shingo Takano - shington4@md.tsukuba.ac.jp; Akira Matsumura - a-matsumur@md.tsukuba.ac.jp

*Corresponding author

Received: 06 May 15  Accepted: 29 July 15  Published: 18 September 15

Abstract

**Background:** The authors report a continuous case series of navigation-guided rigid endoscopic biopsy via the transcortical route for intraparenchymal brain lesions to assess the feasibility and efficacy of the method.

**Methods:** Thirty-four patients with intraparenchymal brain lesions found on neurovisualization underwent navigation-guided rigid endoscopic biopsy. Most of the preoperative diagnoses were glioma WHO Grade II–IV (16 cases) or malignant lymphoma (15 cases). Intraoperative photodynamic diagnosis and intraoperative pathological diagnosis were used in 28 and 29 cases, respectively. In 2 cases with small and deep lesions, intraoperative magnetic resonance imaging was used for confirming the accuracy of the biopsy point.

**Results:** The sampling accuracy determined by postoperative imaging and the definitive diagnosis ratio were 94% (32 out of 34 cases) and 97% (33 out of 34 cases), respectively. There was no postoperative mortality. In 2 patients, mild postoperative permanent morbidity (5.9%), presumably related to this technique, was observed in the early cases in the current group (34 case series).

**Conclusion:** The method was estimated as safe and feasible for diagnostic tissue sampling of intraparenchymal brain lesions.

**Key Words:** Endoscopic biopsy, high-grade glioma, malignant lymphoma, needle biopsy

INTRODUCTION

Various methods of intraparenchymal tumor biopsy in the central nervous system have been proposed to date, and can be roughly divided into the following three categories: Needle biopsy, defined as the use of a biopsy needle; endoscopic biopsy, defined as the use of neuroendoscopy; and open biopsy, defined as the use of microscopy through a small craniotomy. These methods differ in details across institutions, including the use of a stereotactic frame, magnetic resonance imaging (MRI)-based navigation system, and rigid fixation. These techniques have advantages and disadvantages related to sampling accuracy, definitive diagnosis ratio, sample volume, and...
risk of complications.[2-4,6-14,16-20] Our previous study of neuronavigation-guided rigid endoscopic biopsy via the transcortical route showed that the sampling accuracy and the definitive diagnosis ratio were 89% and 100%, respectively, being comparable to those of stereotactic needle biopsy (75% and 87%) or open biopsy (88% and 94%).[18]

Here, we report a continuous case series of navigation-guided rigid endoscopic biopsy via the transcortical route for intraparenchymal brain lesions. The purpose of this retrospective study is to assess the feasibility and efficacy of the rigid endoscopic biopsy.

**PATIENTS AND METHODS**

In this retrospective study, 34 continuous cases of patients with intraparenchymal brain lesions discovered on MRI who underwent navigation-guided rigid endoscopic biopsy between January 2009 and July 2014 at our hospital were enrolled. The rigid endoscopic biopsy was selected for deep lesions (>3 cm from the brain surface) that were typically noneloquent areas of the brain such as deep frontal tumors. Other biopsy techniques were selected for surface lesions and/or lesions near the major vessels (open biopsy), intra- or para-ventricular lesions (ventriculoscopy or open biopsy), and deep lesions that were located near the eloquent areas (needle biopsy or open biopsy).

The method of navigation-guided rigid endoscopic biopsy was described in previous reports.[8,13,18] In short, the patient’s head was fixed with a Mayfield frame under general anesthesia. As shown in Figure 1, a single or dual transparent sheath was inserted into the front of the target lesion under control of the navigation system (StealthStation®; Medtronic, Inc., Minneapolis, MN, USA). Single port technique was typically selected for a deep lesion approximately 3–5 cm from the brain surface, and dual port technique was typically selected for a deeper (approximately 5–6 cm from the brain surface) and/or vascular rich deep lesion (approximately 4–6 cm from the brain surface) in the white matter. Preoperative MRI data were used to plan the entry point, target sites, and trajectories of the navigation system to avoid the eloquent or vascular structures. When the start of the lesion was visible through the rigid endoscope (EndoArm®, Olympus Corp., Tokyo, Japan), three or more sample sets of the suspected pathological tissue were obtained from the target sites of the lesion under control of the navigation system. In most cases, the intraoperative photodynamic diagnosis (PDD) using 5-aminolevulinic acid was performed, and the PDD positive tissue samples were submitted for frozen section intraoperative pathological diagnosis. The biopsy was repeated until the samples were confirmed to contain the pathological tissue.

**RESULTS**

The clinical characteristics of the 34 patients with intraparenchymal brain lesions who underwent rigid endoscopic biopsy via the transcortical route are shown in Table 1. A representative case of navigation-guided rigid endoscopic biopsy for malignant lymphoma in the deep white matter of the left parietal region is shown in Figure 2. The mean age of these patients was 61.6 years. Most of the preoperative diagnoses were glioma WHO Grade II–IV (16 cases) or malignant lymphoma (15 cases). MRI-based navigation system and rigid endoscopy were used in all cases. Single neuro-port was used in 28 cases, and the dual ports were used in 6 cases. PDD and intraoperative pathological diagnosis were performed in 28 and 29 cases, respectively, and the endoscopic biopsy without any intraoperative diagnosis was performed only in 1 early case. In 2 cases with small and deep lesions, the intraoperative MRI was used for confirming the accuracy of the biopsy point. In other
In the present study, the largest case series among other reports using navigation-guided rigid endoscopic biopsy has been analyzed; with the definitive diagnosis ratio of 97% in 34 continuous cases of patients. In 6 cases, intratumoral bleeding, and 1 patient with worsened aphasia due to the enlargement of the biopsy cavity. One patient had complete atrioventricular block after surgery, which was thought to be incidental cardiac trouble independent of the neurosurgical technique. Three cases had asymptomatic minor bleedings in the postresection cavity or in the residual tumor lesion.

**DISCUSSION**

In the present study, the largest case series among other reports using navigation-guided rigid endoscopic biopsy has been analyzed; with the definitive diagnosis ratio of 97% in 34 continuous cases of patients. In 6 cases,
the dual port technique was used to access deeper lesions, resulting in 100% of the definitive diagnosis ratio. Such results were similar to those in smaller case series (100% in 6 cases and 100% in 21 cases) of navigation-guided rigid endoscopic biopsy performed in other institutions.\textsuperscript{10,17} The analysis of medical reports showed that the tissue diagnosis was feasible in 362 out of 387 rigid endoscopic biopsies for intraparenchymal brain lesions (38 cases) as well as in other lesions including those in periventricular and intraventricular location (349 cases), with a diagnostic yield of 93.54%. From this, we can conclude that rigid endoscopic biopsy of brain tumors has a high diagnostic yield.\textsuperscript{11} The results are comparable to those of the previous reports describing other surgical techniques.\textsuperscript{12-14,16,18}

We believe that the key characteristics of the ideal biopsy procedure include (1) accurate sampling using a variety of techniques including neuronavigation, intraoperative PDD, and intraoperative pathological diagnosis, (2) sampling a large volume, and (3) visualization of the intraparenchymal structures during surgery. Although open biopsy might be superior to needle biopsy with regards to these key points, both approaches are not always optional for all biopsy cases, including lesions in some deep areas of the white matter, the brain stem and the basal ganglia. We believe that the navigation-guided rigid endoscopic biopsy is a good alternative to other biopsy methods, except for superficial brain lesions, and brain stem lesions.

PDD might be helpful to immediately evaluate whether an accurate sample is obtained from the intraparenchymal brain lesion, including high-grade glioma and malignant lymphoma diagnosis.\textsuperscript{5,15,19} However, there were some negative-fluorescence cases including 2 patients in our series. In addition, positive fluorescence is not always sufficient for detecting an accurate sample because the surrounding area containing normal tissue can be fluorescently positive. Therefore, a combination of multi-modal techniques including intraoperative pathological diagnosis and PDD might be necessary to ensure accurate sampling from a small target. It should also be taken into consideration that the navigation-guided endoscopic biopsy might prolong the operation time when compared with the stereotactic needle biopsy. However, the needle biopsy has the disadvantage of non-visualization of the intraparenchymal structures. Also in our previous study, stereotactic needle biopsy had the highest complication rate (13%) among the three approaches,\textsuperscript{19} although there was no statistical difference.

CONCLUSION

We have reported 34 cases of the navigation-guided endoscopic biopsy for intraparenchymal brain lesions. This method was concluded to be safe and feasible for diagnostic tissue sampling.

Acknowledgments

We would like to thank Thomas Mayers (Medical English Communication Center, Faculty of Medicine, University of Tsukuba) for native English revision.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Azab WA, Nasim K, Chelghoum A, Parwez A, Salaheddin W. Endoscopic biopsy of brain tumors: Does the technique matter? Surg Neurol Int 2014;5:159.
2. Bernays RL, Kollias SS, Khan N, Brandner S, Meier S, Yonekawa Y. Histological yield, complications, and technological considerations in 114 consecutive frameless stereotactic biopsy procedures aided by open intraoperative magnetic resonance imaging. J Neurosurg 2002;97:354-62.
3. Czyz M, Tabakow P, Weizer A, Lechowitcz-Glogowska BE, Zub LW, Jarmundowicz W. The safety and effectiveness of low field intraoperative MRI guidance in frameless stereotactic biopsies of brain tumours-design and interim analysis of a prospective randomized trial. Neurosurg Rev 2014;37:127-37.
4. Frati A, Pichierrri A, Bastianello S, Raco A, Santoro A, Esposito V, et al. Frameless stereotactic cerebral biopsy: Our experience in 296 cases. Stereotact Funct Neurosurg 2011;89:234-45.
5. Grossman R, Nosske E, Shimony N, Raz M, Ram Z. Intraoperative 5-aminolevulinic acid-induced fluorescence in primary central nervous system lymphoma. J Neurosurg 2014;120:67-9.
6. Jain D, Sharma MC, Sarkar C, Gupta D, Singh M, Mahapatra AK. Comparative analysis of diagnostic accuracy of different brain biopsy procedures. Neur India 2006;54:394-8.
7. Lu Y, Yeung C, Radmanesh A, Wiemann R, Black PM, Golby AJ. Comparative effectiveness of frame-based, frameless, and intraoperative magnetic resonance imaging-guided brain biopsy techniques. World Neurosurg 2015;83:261-8.
8. Masuda Y, Ishikawa E, Takahashi T, Ibara S, Yamamoto T, Zaboronok V, et al. Dual-port technique in navigation-guided endoscopic resection for intraparenchymal brain tumor. Surg Neurol Int 2012;3:335.
9. McGirt MJ, Woodworth GF, Coon AL, Frazier JM, Amundson E, Garonzik L, et al. Independent predictors of morbidity after image-guided stereotactic brain biopsy: A risk assessment of 270 cases. J Neurosurg 2005;102:897-901.
10. Nagahisa S, Watabe T, Sasaki H, Nishiyama Y, Hayashi T, Hasegawa M, et al. Surgical navigation-assisted endoscopic biopsy is feasible for safe and reliable diagnosis of unrespectable solid brain tumors. Neurosurg Rev 2013;36:595-600.
11. Nimsky C, Fujita A, Ganslandt O, von Keller B, Kohmura E, Fahibus R. Frameless stereotactic surgery using intraoperative high-field magnetic resonance imaging. Neurou Med Chir (Tokyo) 2004;44:522-33.
12. Nishihara M, Saayama T, Kudo H, Kohmura E. Morbidity of stereotactic biopsy for intracranial lesions. Koe J Med Sci 2011;56:6148-53.
13. Onuma K, Ishikawa E, Matsuda M, Shibata Y, Satomi K, Yamamoto T, et al. Navigation-guided endoscopic biopsy for pathological diagnosis for intraparenchymal pure germinoma near the ventricular trigone. Surg Neurol Int 2012;3:9.
14. Quinn J, Spiro D, Schuler M. Stereotactic brain biopsy with a low-field intraoperative magnetic resonance imager. Neurosurgery 2011;68:1 Suppl Operative:217-24.
15. Schucht P, Knittel S, Slotboom J, Seidel K, Murek M, Jilch A, et al. S-ALA complete resections go beyond MR contrast enhancement: Shift corrected
volumetric analysis of the extent of resection in surgery for glioblastoma. 
Acta Neurochir (Wien) 2014;156:305-12.
16. Schulder M, Spiro D. Intraoperative MRI for stereotactic biopsy. Acta 
Neurochir Suppl 2011;109:81-7.
17. Tanei T, Nakahara N, Takebayashi S, Hirano M, Nagatani T, Nishihata T, et al. 
Endoscopic biopsy for lesions located in the parenchyma of the brain: 
Preoperative planning based on stereotactic methods. Technical note. Neurol 
Med Chir (Tokyo) 2012;52:617-21.
18. Tsuda K, Ishikawa E, Zaboronok A, Nakai K, Yamamoto T, Sakamoto N, et al.
Navigation-guided endoscopic biopsy for intraparenchymal brain tumor. 
Neurol Med Chir (Tokyo) 2011;51:694-700.
19. Widhalm G, Kiesel B, Woehrner A, Traub-Weidinger T, Preusser M, 
Marosi C, et al. 5-Aminolevulinic acid induced fluorescence is a powerful 
intraoperative marker for precise histopathological grading of gliomas with 
non-significant contrast-enhancement. PLoS One 2013;8:e76988.
20. Yamada K, Goto S, Kochi M, Ushio Y. Stereotactic biopsy for multifocal, 
diffuse, and deep-seated brain tumors using Leksell’s system. J Clin Neurosci 
2004;11:263-7.