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Technical Note

Combination of the tubular retractor and brain spatulas provides an adequate operative field in surgery for deep-seated lesions: Case series and technical note

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Abstract

Background: Surgeries for deep-seated lesions are challenging because making a corridor and observing the interface between lesions and normal brain tissue are difficult. The ViewSite Brain Access System, which is a clear plastic tubular retractor system, is used for resection of deep-seated lesions. However, the tapered shape of this system may result in limitation of the surgical field and cause brain injury to observe the interface between lesions and normal tissue. In this study, we evaluated the usefulness of the combination of ViewSite and brain spatulas.

Methods: Nine patients were retrospectively identified who underwent resection of deep-seated lesions with the combination of Viewsite and brain spatulas. We assessed the extent of resection, prognosis, and quantitative brain injury from postoperative diffusion-weighed imaging (DWI).

Results: There were four total radiographically confirmed resections. Subtotal resection in four patients and partial resection in one with central neurocytoma were achieved because these tumors were strongly adherent to the choroid plexus and ependymal veins. Only one case of metastatic tumor relapsed 6 months after surgery. The mean postoperative high signal on DWI was 3.68 ± 0.80 cm^3.

Conclusions: The combination of ViewSite and brain spatulas provides wide and adequate operative fields to observe the interface between lesions and normal tissue, and to prevent brain injury from excessive retraction pressure on the brain derived from repositioning of the ViewSite. Postoperative 3D volumetric analysis

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shows minimal damage to normal brain tissue. This report may provide new insight into the use of the ViewSite tubular retractor.

Key Words: Brain spatula, deep-seated lesion, tubular retractor, ViewSite

INTRODUCTION

Surgeries for intracranial deep-seated lesions are challenging, despite advancement and improvement of surgical approaches and techniques. Creation and maintenance of a safe corridor into the tumor is critical, as well as the ability to visualize the tumor and surrounding structures during the operation.[11] These lesions have been resected using visualization by microscopy with brain spatulas for decades. Since the introduction of the first self-retaining retractor by Greenberg in 1981, many retractor systems have been used in clinical fields. Surgeons have attempted to resect deep-seated lesions using these novel modalities with either or both the microscope and endoscope.

Recently, the ViewSite Brain Access System (Vycor Medical, Inc., Boca Raton, FL, USA) has been used for resection of deep-seated lesions. The usefulness of this tubular retractor system for brain tumors has been documented in adult[9] and pediatric series.[16] The ViewSite tubular retractor is a transparent plastic tubular retractor system that consists of an introducer inside of a working channel port and is available in three lengths (3, 5, and 7 cm) and four widths (12, 17, 21, and 28 mm). This retractor is designed as a tapered forward edge to minimize disruption of the brain during insertion [Figure 1a]. Recinos *et al*. reported postoperative imaging following use of the ViewSite tubular retractor. They showed minimal T2/fluid-attenuated inversion recovery (FLAIR) changes along the surgical path.[16] This result indicates minimal tissue damage and ischemia. In contrast, because of the tapered shape of this retractor, the width of the forward edge is smaller than that of the reverse edge, and it leads to limitation in the working space [Figure 1b]. Moreover, in many deep-seated lesions, the interface between normal tissue and the lesion is not always clear, and lesions frequently have an irregular border.[12] Moving the ViewSite tubular retractor then becomes necessary to observe the border between the lesion and surrounding normal brain tissue. Whether moving the ViewSite tubular retractor causes excessive brain retraction pressure and leads to morbidity is unclear.

Figure 1: The ViewSite brain retractor. The ViewSite brain retractor is designed as a tapered shape to minimalize disruption to the brain during insertion (a). The width of the forward edge (solid line) is smaller than that of the reverse edge (dashed line) and it leads to limitation in the working space (b)

In this study, we report nine cases of deep-seated lesions, which were resected using the ViewSite tubular retractor and brain spatulas. We analyzed postoperative 3D volumetric changes in diffusion-weighted imaging (DWI).

MATERIALS AND METHODS

Patients

Patients with intracranial deep-seated lesions who were treated using both the ViewSite tubular retractor and brain spatulas were identified from the medical records of Okayama University Hospital from March 2013 to October 2016. Medical charts were reviewed for age at presentation, sex, clinical presentation, radiographic imaging, operation record, pathological findings, treatment, and outcome. This study (no. 1703-011) was approved by the ethical committee of the Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama, Japan.

Surgical techniques

Preoperatively, for the neuronavigation system, computed tomography (CT) imaging and contrast-enhanced magnetic resonance imaging (MRI) were performed. When the lesion was adjacent to the eloquent area, functional MRI and diffusion tensor imaging (DTI) were also achieved. Using these images, either Curve™ Image Guided Surgery (BrainLab, Munich, Germany), StealthStation S7 (Medtronic Inc., Louisville, CO, USA), or StealthStation Treon (Medtronic Inc.) was registered, and the surgical trajectory was planned to avoid the eloquent area and critical vasculature. After corticotomy was performed over a non-eloquent gyrus, the ViewSite tubular retractor was gently inserted along the previously planned surgical tract. As mentioned above, there are several sizes of the ViewSite tubular retractor. Therefore, the distance from the entry point of parenchyma to the lesion was measured on images to decide which retractor was suitable. We usually selected 17- and 21-mm-wide retractors in the 7 cm lengths. After setting the ViewSite tubular retractor in the proper position, the retractor was fixed with a self-retaining Leyla arm (Aesculap, Tuttlingen, Germany), and the introducer was removed. We then resected lesions through the ViewSite tubular retractor under a surgical microscope (OPMI Pentero or NC4; Carl Zeiss Co., Oberkochen, Germany) and/or an endoscope (Karl Storz Endoscopy, Tuttlingen, Germany) [Figure 2a and b]. The majority of lesions were resected. The ViewSite tubular retractor was then removed, and we used a malleable brain spatula (Fujita Medical Instruments Co., Ltd., Tokyo, Japan) to observe the interface between normal tissue and lesions and to remove residual lesions [Figure 2c and d].

At the end of resection, a ventriculostomy catheter was placed at the intraventricular space in ventricular tumor surgery. Finally, the dura mater, the bone flap, and skin were closed in a standard fashion.

Volumetric analysis

Researcher who was not involved in the surgical procedure of the patients in this study conducted the volumetric analysis described below. Postoperative radiographic MRI was imported into BrainLab software for volumetric analysis.

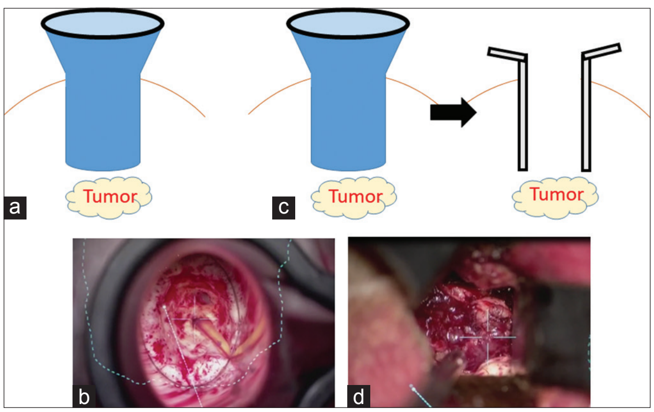

Figure 2: Illustration depicting surgical approaches to deep-seated lesions with the ViewSite tubular retractor or brain spatulas. When only using the ViewSite tubular retractor, the surgical field is limited because of its tapered shape (a and b). However, using brain spatulas after making a corridor to the lesion with the ViewSite tubular retractor provides an adequate surgical field (c and d)

DWI (b-value; 1000) was used because restricted diffusion on DWI is a marker for brain cytotoxic edema and ischemic or cell damage.[3] Using iPlan 3.0 Cranial® (BrainLab), objects were drawn to measure 3D volumes. The extent of resection (EOR) was also calculated. Gross total resection (GTR) was considered EOR >99%, subtotal resection (STR) 95%–99%, and partial resection (PR) <95%.

RESULTS

A comprehensive list of the patients is shown in Table 1. Among the nine cases, the mean age was 57 ± 5.5 years, and five patients were men (55.6%). Histologically, five patients were diagnosed with central neurocytoma in which all of the tumors were located in the lateral ventricle, two patients had a metastatic brain tumor, one patient had glioblastoma multiforme, and one patient had cavernous angioma in the third ventricle. There were four total radiographically confirmed resections (44.4%). STR and PR were achieved in four (44.4%) patients and in one (11.1%) patient with central neurocytoma, respectively, because these tumors were strongly adherent to the choroid plexus and ependymal veins. Postoperatively, there was no morbidity, including cerebrospinal fluid leakage, worsened neurological symptoms, and postoperative hematoma for this procedure. There was no perioperative death. Only one case of metastatic tumor relapsed after 6 months after the patient's first surgery (case 5).This patient had a second surgery and CyberKnife treatment. Postoperative DWI was taken in five patients. The mean postoperative DWI high signal was 3.68 ± 0.80 cm^3.

Illustrative case

A 56-year-old woman was transferred to our hospital with sensory disturbance in her left arm and leg. MRI of the head showed a 29-mm tumor in the right frontal and parietal lobes. The tumor had a necrotic area in the center of the tumor. After administration

Table 1: Characteristics of the patients

Case	Age, Gender	Diagnosis	Tumor location	Resection	Permanent morbidity	Recurrence
1	34, M	Central neurocytoma	Rt. LV	STR	None	None
2	41, M	Central neurocytoma	Lt. LV	STR	None	None
3	65, F	Cavernous angioma	3^{rd} V	GTR	None	None
4	41, M	Central neurocytoma	Lt. LV	STR	None	None
5	76, M	Metastatic brain tumor	Rt. Parietal	GTR	None	Recurrence
6	56, F	GBM	Rt. Frontoparietal	GTR	None	None
7	73, F	Central neurocytoma	Lt. LV	STR	None	None
8	50, F	Central neurocytoma	Rt. LV	PR	None	None
9	77, M	Metastatic brain tumor	Rt. Parietal	GTR	None	None

GBM=glioblastoma multiforme, LV=lateral ventricle, GTR=gross total resection, PR=partial resection, STR=subtotal resection

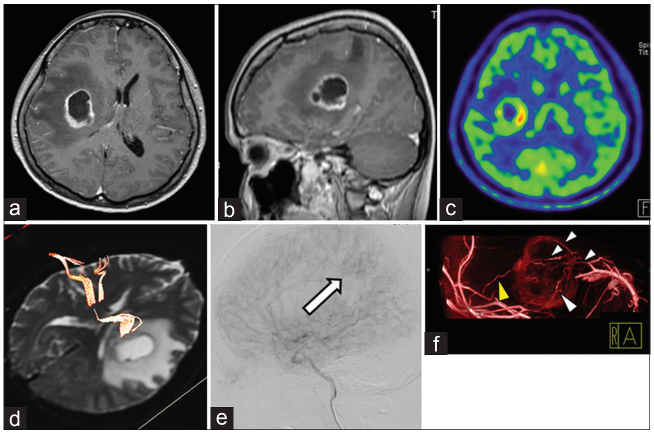

Figure 3: Preoperative imaging of an illustrative case. Preoperative contrast-enhanced axial (a) and sagittal (b) MRI shows a 29-mm tumor in the right frontal and parietal lobes. ^{11}C-methionine positron emission tomography shows high uptake (c), and DTI shows that the corticospinal tract is present in the front of and adjacent to the tumor itself (d). Digital subtraction angiogram shows tumor staining (e, arrow). Contrast-enhanced cone-beam CT shows that main feeding arteries (yellow arrowhead) from the right middle cerebral artery are located in the lateral part of the tumor, and draining veins (white arrowhead) are in the medial portion of the tumor (f)

of contrast enhancement, the tumor showed ring enhancement [Figure 3a and b]. ^{11}C-methionine positron emission tomography showed high uptake [Figure 3c], and DTI showed the presence of a corticospinal tract in the front of and adjacent to the tumor itself [Figure 3d]. A digital subtraction angiogram showed tumor staining through the right middle cerebral artery [Figure 3e]. Contrast-enhanced cone beam CT and a fusion image of contrast-enhanced cone beam CT and gadolinium enhanced T1 weighted image showed that the main feeding arteries were located in the lateral part of the tumor, and draining veins were in the medial portion of the tumor [Figure 3f and Supplementary Figure 1]. To avoid injury of the corticospinal tract, a direct path was planned from the cortex of the parietal lobe. The ViewSite tubular retractor was gently inserted and placed using neuronavigation. The tumor was observed and resected through the ViewSite tubular retractor under a microscope and endoscope. The nature of the tumor was soft and hypervascular. Subsequently, we switched the ViewSite tubular retractor into brain spatulas to identify and sacrifice the feeding artery, which was present in the interface between the normal brain and lesion. We sacrificed the feeding artery and removed the residual tumor under a microscope. Finally, carmustine (bis-chloroethylnitrosourea [BCNU]) implants (Gliadel Wafer; Eisai Inc., Woodcliff Lake, NJ, USA) were placed on the surface of the resected tumor beds.

Postoperative MRI showed GTR [Figure 4a and b], and the patient was neurologically intact with no morbidity. Three-dimensional volumetric analysis

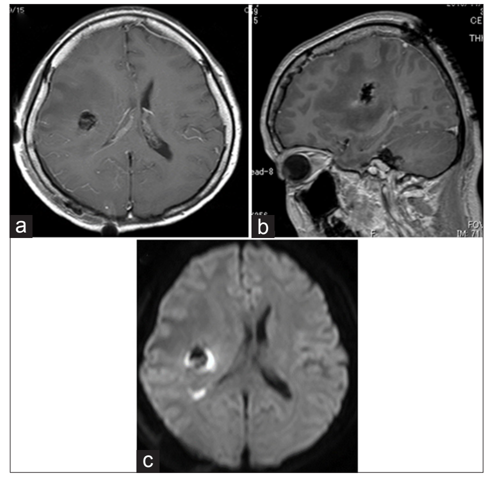

Figure 4: Postoperative imaging of the illustrative case. Preoperative contrast-enhanced axial (a) and sagittal (b) MRI shows gross total resection. Three-dimensional volumetric analysis of restricted diffusion on DWI was performed (c)

of restricted diffusion on DWI showed 6.03 cm^3 [Figure 4c]. Hematoxylin–eosin staining showed highly cellularity, prominent microvascular proliferation, and pseudopalisading necrosis. She was diagnosed with glioblastoma, and she then received a standard radiotherapy (60 Gy). Twelve months after the operation, MRI showed no recurrence of the tumor.

DISCUSSION

Surgeries for deep-seated lesions are challenging because creating a corridor and observing the interface between lesions and normal brain tissue are difficult. To solve these problems, many brain retraction systems combined with a microscope or endoscope have been introduced. First, the self-retaining retraction system by Greenberg was introduced in 1981.[6] However, the danger of brain infarction and brain damage due to excessive brain retraction pressure has been debated. Rosenorn *et al*. reported a reduction in regional cerebral blood flow in the brain cortex lying under the retractor with 20 mmHg of brain retractor pressure using rat models.[17] In the human brain, the threshold for ischemia and contusion are estimated to be less than 30mmHg.[8] Additionally, systemic intraoperative factors, such as blood loss, acidosis, hypotension, and metabolic abnormalities, can increase the risk of cerebral ischemia resulting from a brain retractor.[1,2,16] Since these studies, many neurosurgeons have suggested the advantage of a tubular retractor system. This system can distribute the forces of retraction evenly and reduce brain retraction pressure to normal surrounding tissue compared with traditional retractors.[3,5,7,9,16,20] Ogura *et al*. invented a cylinder with a 0.1-mm transparent polyester film to create a cylindrical surgical route.[15] Of particular importance, they evaluated brain retractor pressure on surrounding tissue, and it was less than 10 mmHg, which is lower than the critical threshold for cerebral ischemia suggested by Rosenorn.[17]

The ViewSite tubular retractor is a specially tailored tubular retractor for neurosurgery and applied for removal of intraparenchymal or intraventricular tumors, hemorrhage, and foreign bodies.[9,14,16,18] The ViewSite tubular retractor is not only used for the transcortical approach but also for the interhemispheric transcallosal approach for the third ventricle,[19] or middle fossa approach for intracanalicular tumors.[4] This retractor has many advantages. First, the ViewSite tubular retractor may decrease damage to normal brain tissue. As mentioned above, Recinos *et al*. reported postoperative imaging following use of the ViewSite tubular retractor and showed minimal T2/FLAIR changes along the surgical path.[16] Additionally, this retractor is composed of plastic and has a tapered end, which prevents electrical transmission and allows adjacent tissue to be visualized. Additionally, the ViewSite tubular retractor can be secured onto a self-retracting arm, such as the Greenberg or Leyla bar systems, to prevent shifting of the operation field.[16] However, there are two disadvantages of the ViewSite tubular retractor. First, the area of the forward edge is significantly smaller than that of the reverse edge because of its unique tapered shape[13] [Figure 1b]. This leads to limitation in working space [Figure 2a and b]. In cases, where surgeries are completely performed with the ViewSite tubular retractor, an endoscope, and modified microsurgical instruments for endoscopic surgery, this disadvantage of the limitation in working space may be overcome. However, for deep-seated hypervascular tumors, such as glioblastoma multiforme, binocular, and 3D vision provided by a microscope provides more information and leads to safer resections than with an endoscope.[10] In these cases, a small working space restricts the use of microsurgical instruments. Second, in many deep-seated lesions, the interface between normal tissue and the lesion is not always clear, and lesions frequently have an irregular border.[12] Therefore, the border of the lesion should be carefully observed to achieve gross total resection. Recinos *et al*. reported that the ViewSite tubular retractor can easily be moved and repositioned for approaching irregular lesions.[16]However, we speculate whether this retractor can cause excessive brain pressure because its shape cannot be changed freely. In contrast, brain spatulas are familiar instruments for neurosurgeons and suitable for overcoming these disadvantages. When brain spatulas are used after making a corridor by the ViewSite tubular retractor, normal brain tissue does not need to be retracted with excessive pressure because a path to the lesion has already been made and retained. Additionally, brain spatulas enable retraction of the normal brain locally. Therefore, brain spatulas can provide larger operative fields than the ViewSite brain retractor and adequate operative fields for observing the interface between lesions and normal tissue. Brain spatulas can also prevent brain injury from excessive brain pressure derived from repositioning of the ViewSite tubular retractor. In this study, we evaluated restricted diffusion on DWI as a marker for brain cytotoxic edema and ischemic or cell damage. To the best our knowledge, only one study quantitatively evaluated brain damage resulting from a retractor using postoperative MRI.[3] In this previous study, the authors used the METRx tubular retractor system for deep intraparenchymal lesions. They reported that postoperative DWI volume (8.35 ± 3.05 cm^3) tended to be lower than that of the traditional retractor (16.51 ± 8.9 cm^3). In our series, postoperative DWI volume was lower than previously reported.[3] Therefore, the combination of the ViewSite tubular retractor and brain spatulas may provide less damage to normal brain tissue.

The concept of tubular retractor was proposed more than 30 years ago, and their efficacy and safety have been reported numerously compared with traditional blade retractors that may cause asymmetric tension on brain tissue. By contrast, we also feel the disadvantages of tubular retractor, which are the limitation of working space and observing irregular border of deep-seated lesions. The brain spatulas compensate these disadvantages, and we can provide minimally invasive surgery by using the combination of the ViewSite tubular retractor and brain spatulas technique.

CONCLUSION

In conclusion, we first introduced the combination of the ViewSite tubular retractor and brain spatulas to overcome the disadvantage of the ViewSite tubular retractor, including the limitation in the area and view of the operative field. Our results may provide new insight into the use of the ViewSite tubular retractor.

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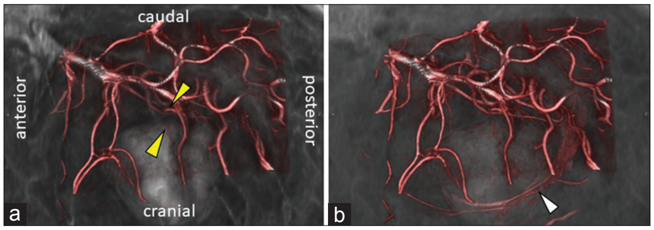
Conflicts of interest
All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval
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.

REFERENCES

1. Albin MS, Bunegin L. The insidiousness of brain retractor pressure: Another "Smoking gun"? AnesthAnalg 2003;96:306; author reply 306-7.
2. Andrews RJ, Bringas JR. A review of brain retraction and recommendations for minimizing intraoperative brain injury. Neurosurgery 1993;33:1052-63; discussion 1063-54.
3. Bander ED, Jones SH, Kovanlikaya I, Schwartz TH. Utility of tubular retractors to minimize surgical brain injury in the removal of deep intraparenchymal lesions: A quantitative analysis of FLAIR hyperintensity and apparent diffusion coefficient maps. JNeurosurg 2016;124:1053-60.
4. Bernardo A, Evins AI, Tsiouris AJ, Stieg PE. A Percutaneous transtubular middle fossa approach for intracanalicular tumors. World Neurosurg 2015;84:132-46.
5. Fahim DK, Relyea K, Nayar VV, Fox BD, Whitehead WE, Curry DJ, *et al*. Transtubular microendoscopic approach for resection of a choroidal arteriovenous malformation. JNeurosurg Pediatr 2009;3:101-4.
6. Greenberg I. Self-retaining retractor and handrest system for neurosurgery. Neurosurgery 1981;8:205-8.
7. Greenfield JP, Cobb WS, Tsouris AJ, Schwartz TH. Stereotactic minimally invasive tubular retractor system for deep brain lesions. Neurosurgery 2008;63(Suppl 2):334-9; discussion 339-340.
8. Harada S, Nakamura T. Retraction induced brain edema. Acta Neurochir Suppl (Wien) 1994;60:449-51.
9. Herrera SR, Shin JH, Chan M, Kouloumberis P, Goellner E, Slavin KV. Use of transparent plastic tubular retractor in surgery for deep brain lesions: A case series. SurgTechnol Int 2010;19:47-50.
10. Ichikawa T, Otani Y, Ishida J, Fujii K, Kurozumi K, Ono S, *et al*. Hybrid microscopic-endoscopic surgery for craniopharyngioma in neurosurgical suite: Technical notes. World Neurosurg 2016;85:340-8.e1.
11. Kassam AB, Engh JA, Mintz AH, Prevedello DM. Completely endoscopic resection of intraparenchymal brain tumors. JNeurosurg 2009;110:116-23.
12. Kelly PJ. Future perspectives in stereotactic neurosurgery: Stereotactic microsurgical removal of deep brain tumors. JNeurosurg Sci 1989;33:149-54.
13. Kishida Y, Sato T, Oda K, Ichikawa M, Sakuma J, Saito K. Pure endoscopic resection of deep intracranial tumors using the ViewSite Brain Access System. No shinkei geka 2014;42:311-25.
14. Matsumoto Y, Kurozumi K, Shimazu Y, Ichikawa T, Date I. Endoscope-assisted resection of cavernous angioma at the foramen of Monro: A case report. Springerplus 2016;5:1820.
15. Ogura K, Tachibana E, Aoshima C, Sumitomo M. New microsurgical technique for intraparenchymal lesions of the brain: Transcylinder approach. Acta Neurochir (Wien) 2006;148:779-85; discussion 785.
16. Recinos PF, Raza SM, Jallo GI, Recinos VR. Use of a minimally invasive tubular retraction system for deep-seated tumors in pediatric patients. JNeurosurg Pediatr 2011;7:516-21.
17. Rosenorn J, Diemer NH. Reduction of regional cerebral blood flow during brain retraction pressure in the rat. JNeurosurg 1982;56:826-9.
18. Rymarczuk GN, Davidson L, Severson MA, Armonda RA. Use of a minimally invasive retractor system for retrieval of intracranial fragments in wartime trauma. World Neurosurg 2015;84:1055-61.
19. Shoakazemi A, Evins AI, Burrell JC, Stieg PE, Bernardo A. A 3D endoscopic transtubular transcallosal approach to the third ventricle. JNeurosurg 2015;122:564-73.
20. Yadav YR, Yadav S, Sherekar S, Parihar V. A new minimally invasive tubular brain retractor system for surgery of deep intracerebral hematoma. Neurol India 2011;59:74-7.



Supplementary Figure 1: A fusion image of contrast-enhanced cone beam CT and gadolinium enhanced T1 weighted image of an illustrative case. A fusion image of contrast-enhanced cone beam CT and gadolinium enhanced T1 weighted image showed that the main feeding arteries (yellow arrowhead) from the right middle cerebral artery (a) and draining veins that connected to thalamostriate vein (b, white arrowhead)