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Technical Notes

Surgical resection of glioblastoma in basal ganglia and utility of exoscope: Technical case reports

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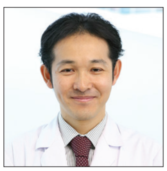

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ABSTRACT

Background: Due to the presence of many perforating arteries and the deep location of basal ganglia tumors, dissection of the perforating arteries is critical during tumor resection. However, this is challenging as these arteries are deeply embedded in the cerebrum. Surgeons need to bend their heads for a long time using operative microscope and it is uncomfortable for the operating surgeon. A high-definition (4K-HD) 3D exoscope system can significantly improve the surgeon's posture during resection and widen the operating view field considerably by adjusting the camera angle.

Methods: We report two cases of glioblastoma (GBM) involving basal ganglia. We used a 4K-HD 3D exoscope system for resecting the tumor and analyzed the intraoperative visualization of the operative fields.

Results: We could approach the deeply located feeding arteries before successfully resecting the tumor using a 4K-HD 3D exoscope system which would have been difficult with the sole use of an operative microscope. The postoperative recoveries were uneventful in both cases. However, postoperative magnetic resonance imaging showed infarction around the caudate head and corona radiata in one of the cases.

Conclusion: This study has highlighted using a 4K-HD 3D exoscope system in dissecting GBM involving basal ganglia. Although postoperative infarction is a risk, we could successfully visualize and dissect the tumors with minimal neurological deficits.

Keywords: Basal ganglia glioblastoma, Exoscope, Neurosurgery, Operating microscope, Tumor

INTRODUCTION

Resections for basal ganglia tumors are challenging because the lesions are deeply located, and many perforating arteries traverse through this area. Thus, the prognosis of basal ganglia glioblastoma (GBM) is poor,[2,6] with a total resection rate of 50%.[2] Recent studies reported a resectability map of basal ganglia lesions, which suggested that they are partly resectable.[13] Further, in approximately 50% of cases, deeply located GBM can undergo gross total resection.[2]

GBM frequently presents as a hypervascular tumor and is located in the basal ganglia and supplied by perforating arteries from the anterior cerebral artery (ACA), middle cerebral artery (MCA), and posterior cerebral artery (PCA).[17] It is important to dissect and coagulate feeding arteries at the beginning of the surgery to minimize intraoperative bleeding during surgical resections.[12] However, it is sometimes difficult to achieve this since feeding arteries can be located deep into the cerebrum, such as within the basal ganglia. Moreover, basal ganglia tumors sometimes extend into the lateral ventricle.[15,20] Therefore, while resecting such a tumor in the basal ganglia using a conventional operative microscope, the surgeon is forced to operate in head-down position, which is uncomfortable On the other hand, surgeons do not need to bend their heads for a long time using exoscope. Studies have shown that a recently introduced high-definition (4K-HD) 3D exoscope system, ORBEYE (Olympus, Tokyo, Japan), can help dissect such deep-seated tumors by significantly improving the surgeon's posture[8-10,14] and widening the operative view field by adjusting the camera angle.[9,11]

In this report, we discuss two cases of GBM located in the basal ganglia, which was successfully resected by approaching the deeply located feeding arteries using a recently developed 4K-3D exoscope system, ORBEYE.

CASE ILLUSTRATION

Case 1

Clinical background

A 74-year-old previously independent woman presented to our neurosurgical department with difficulty walking, right-sided mild hemiparesis, and cognitive impairment. Her right side manual muscle test (MMT) was 4, and she was slightly disorientated, although she is almost independent. She did not show any other neurological deficits. Magnetic resonance imaging (MRI) showed both left-sided basal ganglia and parietal tumors. The basal ganglia tumor was heterogeneously enhanced using gadolinium (Gd) with peripheral edema by fluid-attenuated inversion recovery imaging. This tumor extended upward toward the left lateral ventricle and presented with hydrocephalus. Further, malignant glioma was suspected as it was surrounded by severe peritumoral edema. Moreover, the left parietal tumor suggested meningioma because it showed the dural tail sign. Thus, we planned resection of the basal ganglia tumor [Figures 1a-e] after digital subtraction angiography, which confirmed that it was supplied by perforating arteries from the ACA and MCA [Figure 1f].

Operative procedure

Two different approaches can be used for resecting this tumor, that is, the transsylvian approach and transcortical approach. Using the transsylvian approach, we can visualize and coagulate feeding arteries from the MCA and ACA before resecting the tumor. However, using the transcortical approach, we can visualize them during the later stage of the operation. Although the tumor extended toward the left lateral ventricle, we thought that we could visualize the intraventricular tumor using ORBEYE; therefore, we chose the transsylvian approach for resecting the tumor.

We performed left ventricular drainage into the left lateral ventricle, followed by left frontotemporal craniotomy [Figure 2]. We dissected the sylvian fissure and visualized the MCA, internal carotid artery, ACA, and optic nerve. We identified the ACA perforating arteries supplied to the tumor, including the recurrent artery of Heubner [Figure 3a]. Angiographical findings suggest that ACA perforating arteries, including the recurrent artery of Heubner, supplied exclusively to the tumor; thus, we considered that no new neurological deficit would occur when dissecting these arteries. Hence, we dissected and coagulated these feeding arteries [Figure 3b]. This was followed by dissection of the medial frontal lobe and removal of the tumor, which was not extensively hemorrhagic after coagulation of the feeding arteries. Although the margins between the tumor and cerebrum were unclear, the upper margin of the tumor, which was located in the lateral ventricle, was visualized and safely resected using ORBEYE [Figures 3c and d]. 5-amino levulinic acid (5-ALA) was also used to visualize and resect the tumor.

Postoperative course

The postoperative recovery was uneventful, and the patient was discharged home with a Karnofsky Performance Status (KPS) score of 90. Her postoperative MRI showed no enhanced lesions [Figures 4a-d]. However, diffusion-weighted images showed infarction around the caudate head and corona radiata [Figure 4e]. Histopathological examination revealed GBM of the isocitrate dehydrogenase (IDH) wild type, following which she underwent radiotherapy (60 Gy/30 Fr) and treatment using temozolomide.

Case 2

Clinical background

A 50-year-old previously independent man presented to our neurosurgical department with memory loss and headache. His right side MMT was 5, and he had slight memory loss, although he is independent. His Mini-Mental State Examination score was 28. MRI showed a left temporal lobe tumor extending into the basal ganglia. The tumor was heterogeneously enhanced using Gd with cyst formation. The tumor extended toward the external capsule. GBM was suspected as it was surrounded by severe peritumoral edema. We planned resection of the tumor with the lateral leticulostriate artery (LSA) compressed medial to the tumor [Figures 5a-c].

Operative procedure

We performed left frontotemporal craniotomy and corticotomy in the middle temporal gyrus. We aspirated

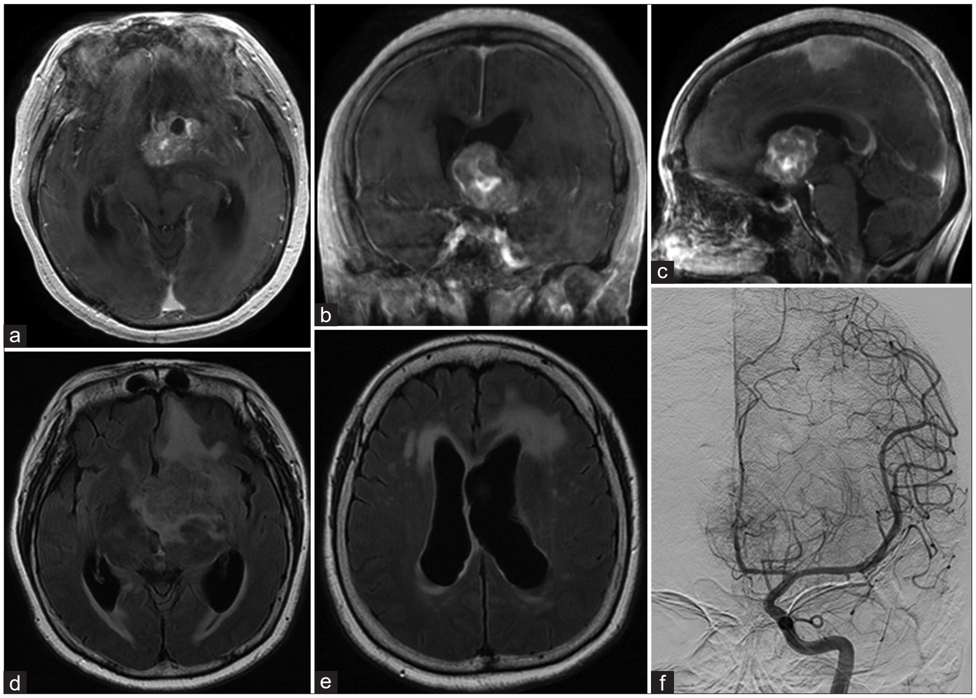

Figure 1: Preoperative magnetic resonance imaging (MRI) scans of the Case1 patient. (a-c) show gadolinium-enhanced MRI images, (d and e) show fluid-attenuated inversion recovery images, while (f) shows left internal carotid artery angiography.

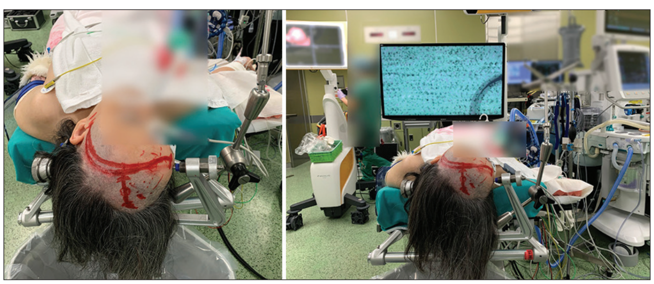

Figure 2: Patient's position during surgery. The patients are placed in the supine position with the head facing 30° to the right, and the left ventricular drainage is inserted from the left frontal lobe.

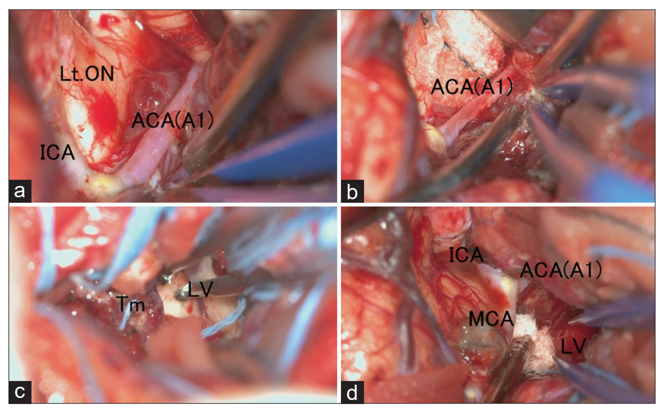

Figure 3: Intraoperative images of the Case 1 patient. (a) shows the A1 perforator that supplied the tumor, (b) demonstrates coagulation of the recurrent artery of Heubner to manage the hemorrhagic tumor, (c) demonstrates the lateral ventricle visualized by adjusting the camera angle, and (d) represents the final view of the operative field. ICA: Internal carotid artery, Lt.ON: Left optive nerve, ACA: Anterior cerebral artery, Tm: Tumor, LV: Lateral ventricle, MCA: Middle cerebral artery.

the cyst and dissected the lateral part of the tumor in the temporal lobe. This was followed by the dissection of the medial part of the tumor and visualization in the basal ganglia. Although the margins between the tumor and cerebrum were unclear, the anteromedial margin of the tumor, which was located in the basal ganglia, was visualized and safely resected using ORBEYE and 5-ALA [Figures 6a and b]. The tumor was not extensively hemorrhagic; however, we needed to be careful not to damage the LSA located medially.

Postoperative course

The postoperative recovery was uneventful, and the patient was discharged home with a KPS score of 90. His postoperative MRI showed that most of the enhanced tumor was removed without any infarction of LSA-perfused area, but a slight residual tumor was present [Figures 7a-c]. Histopathological examination revealed GBM of the IDH wild type, following which he underwent radiotherapy (60 Gy/30 Fr) and treatment with temozolomide.

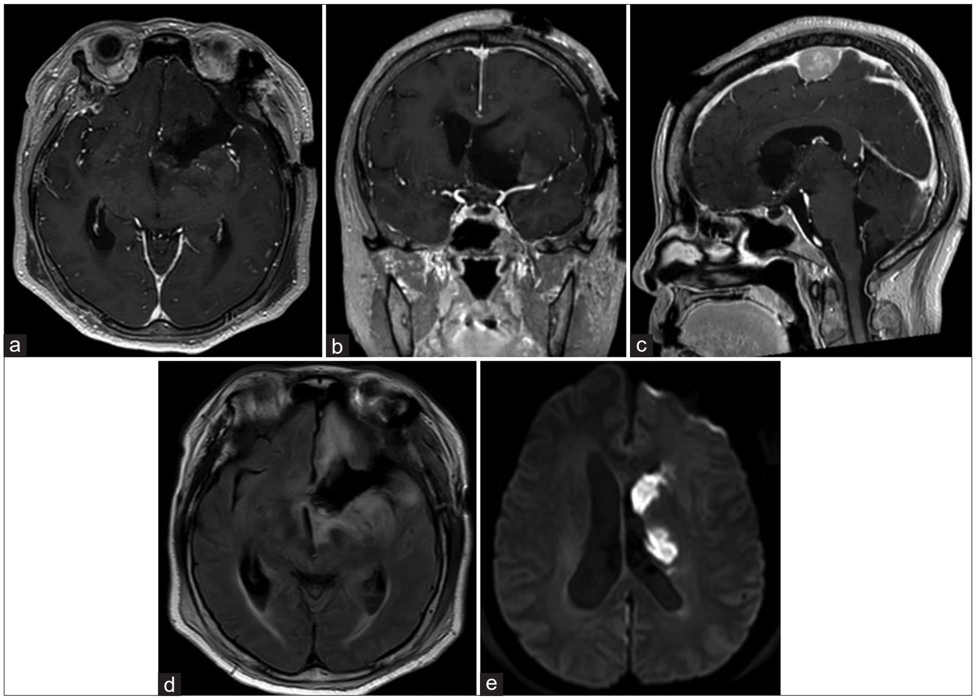

Figure 4: Postoperative magnetic resonance imaging (MRI) scans of the Case 1 patient. (a-c) represent gadolinium-enhanced MRI, which shows complete resection of the enhanced tumor, (d) shows the fluid-attenuated inversion recovery image, and (e) represents the diffusion-weighted imaging image.

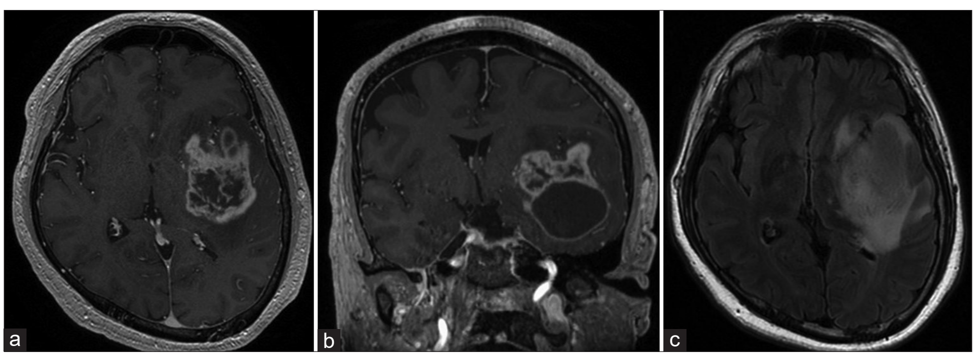

Figure 5: Preoperative magnetic resonance imaging (MRI) scans of the Case 2 patient. (a and b) show gadolinium-enhanced MRI images, (c) shows fluid-attenuated inversion recovery image.

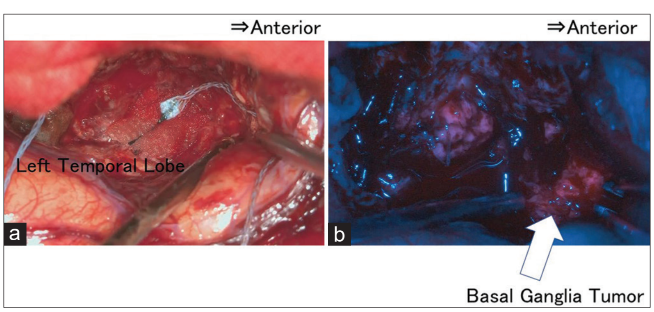

Figure 6: Intraoperative images of the Case 2 patient. (a) demonstrates the basal ganglia lesions visualized by adjusting the camera angle, and (b) represents the intraoperative view of 5-amino levulinic acid, which could visualize the residual tumor within the basal ganglia.

DISCUSSION

The outcomes of our case are consistent with the results of previous studies suggesting that the basal ganglia lesions are deep-seated and that the basal ganglia are not a common location of GBM; thus, resections of basal ganglia tumors are not extensively reported because their resections are challenging.[3,5] Moreover, many perforating arteries arising from the ACA, MCA, and PCA traverse through this area and can cause postoperative infarctions.[4,17] However, little is known regarding whether these perforating arteries can be sacrificed to resect basal ganglia tumors. In the first case, we achieved complete resection of the basal ganglia

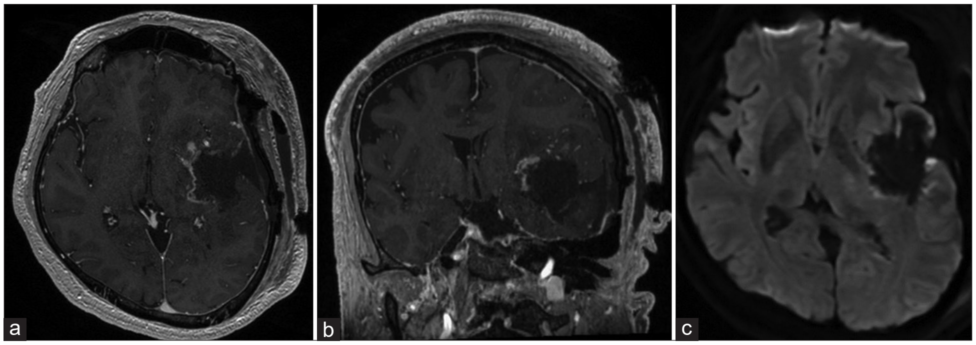

Figure 7: Postoperative magnetic resonance imaging (MRI) scans of the Case 2 patient. (a and b) represent gadolinium-enhanced MRI, which shows that most of the enhanced tumor was removed. (c) represents the diffusion-weighted imaging image, which shows no infarction of leticulostriate artery -perfused area.

GBM without worsening neurological signs. However, postoperative MRI showed infarction at the sites of supply of the perforating arteries.

Furthermore, the newly developed exoscope system, ORBEYE, also contributed to the resections of the basal ganglia tumors. In the first case, the tumor extended upward into the lateral ventricle, necessitating a combination of the transsylvian and transcortical transventricular approaches using an operative microscope. However, we could visualize the intraventricular tumor by adjusting the ORBEYE camera angle, which was otherwise difficult using the conventional microscope.[21] This is because the surgeon's position and camera angle during surgery are restricted while viewing through the operative microscopic lens. In the second case, the temporal tumor extended toward the basal ganglia. We could visualize the tumor extending toward the basal ganglia by adjusting the ORBEYE camera angle.

The recently introduced 4K-HD 3D exoscope system, ORBEYE, can offer more favorable ergonomics, optics, and maneuverability than the operative microscope. The previous studies compared the utility of the ORBEYE exoscope system with that of the operative microscope.[9,16,18,19] They reported that ORBEYE is ergonomically more favorable than the operative microscope and allows the surgeon to perform the surgery in a more neutral position.[1,7,9,19]

In addition, learning curve of using exoscope system is also reported. The previous studies reported that exoscopes have a shorter learning curve than the operative microscope.[16,19] However, the surgeons need to get used to wearing 3D glasses because eye strain from wearing the 3D glasses was reported.[1]

Thus, ORBEYE may enable neurosurgical procedures that were previously difficult for the surgeon, including procedures such as basal ganglia tumor resections, gravity-assisted brain retraction surgeries for midline brain tumors,[9] and keyhole surgeries.[11]

CONCLUSION

Resecting deeply seated GBM involving basal ganglia using a 4K-HD 3D exoscope system are feasible and 4K-HD 3D exoscope system can provide improved visualization to the surgeon. Although deeply seated GBM have many perforating arteries and postoperative infarction is a risk, we could successfully visualize and dissect deeply seated GBM with minimal neurological deficits by 4K-HD 3D exoscope system.

Ethical standards

This analysis was approved by the Institutional Review Board, and the patient gave informed consent before inclusion in this study.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Ahmad FI, Mericli AF, DeFazio MV, Chang EI, Hanasono MM, Pederson WC, *et al*. Application of the ORBEYE three-dimensional exoscope for microsurgical procedures. Microsurgery 2020;40:468-72.
2. Barsouk A, Baldassari MP, Khanna O, Andrews CE, Ye DY, Velagapudi L, *et al*. Glioblastoma with deep supratentorial extension is associated with a worse overall survival. J Clin Neurosci 2021;93:82-7.

3. Briggs RG, Nix CE, Conner AK, Palejwala AH, Smitherman AD, Teo C, *et al*. An awake contralateral, transcallosal approach for deep-seated gliomas of the basal ganglia. World Neurosurg 2019;130:e880-7.
4. Djulejić V, Marinković S, Georgievski B, Stijak L, Aksić M, Puškaš L, *et al*. Clinical significance of blood supply to the internal capsule and basal ganglia. J Clin Neurosci 2016;25:19-26.
5. Franzini A, Leocata F, Cajola L, Servello D, Allegranza A, Broggi G. Low-grade glial tumors in basal ganglia and thalamus: Natural history and biological reappraisal. Neurosurgery 1994;35:817-20; discussion 820.
6. Fyllingen EH, Bø LE, Reinertsen I, Jakola AS, Sagberg LM, Berntsen EM, *et al*. Survival of glioblastoma in relation to tumor location: A statistical tumor atlas of a population-based cohort. Acta Neurochir (Wien) 2021;163:1895-905.
7. Izumo T, Ujifuku K, Baba S, Morofuji Y, Horie N, Matsuo T. Initial experience of ORBEYE™ surgical microscope for carotid endarterectomy. Asian J Neurosurg 2019;14:839-42.
8. Khalessi AA, Rahme R, Rennert RC, Borgas P, Steinberg JA, White TG, *et al*. First-in-man clinical experience using a high-definition 3-dimensional exoscope system for microneurosurgery. Oper Neurosurg (Hagerstown) 2019;16:717-25.
9. Kijima N, Kinoshita M, Takagaki M, Kishima H. Utility of a novel exoscope, ORBEYE, in gravity-assisted brain retraction surgery for midline lesions of the brain. Surg Neurol Int 2021;12:339.
10. Kwan K, Schneider JR, Du V, Falting L, Boockvar JA, Oren J, *et al*. Lessons learned using a high-definition 3- dimensional exoscope for spinal surgery. Oper Neurosurg (Hagerstown) 2019;16:619-25.
11. Langer DJ, White TG, Schulder M, Boockvar JA, Labib M, Lawton MT. Advances in intraoperative optics: A brief review of current exoscope platforms. Oper Neurosurg (Hagerstown) 2020;19:84-93.
12. Mortazavi MM, Jazi GA, Sadati M, Zakowicz K, Sheikh S, Khalili K, *et al*. Modern operative nuances for the management of eloquent high-grade gliomas. J Neurosurg Sci 2019;63:135-61.
13. Müller DM, Robe PA, Eijgelaar RS, Witte MG, Visser M, de Munck JC, *et al*. Comparing glioblastoma surgery decisions between teams using brain maps of tumor locations, biopsies, and resections. JCO Clin Cancer Inform 2019;3:1-12.
14. Nossek E, Schneider JR, Kwan K, Kulason KO, Du V, Chakraborty S, *et al*. Technical aspects and operative nuances using a high-definition 3-dimensional exoscope for cerebral bypass surgery. Oper Neurosurg (Hagerstown) 2019;17:157-63.
15. Roth J, Ram Z, Constantini S. Endoscopic considerations treating hydrocephalus caused by basal ganglia and large thalamic tumors. Surg Neurol Int 2015;2:56.
16. Sack J, Steinberg JA, Rennert RC, Hatefi D, Pannell JS, Levy M, *et al*. Initial experience using a high- definition 3-dimensional exoscope system for microneurosurgery. Oper Neurosurg (Hagerstown) 2018;14:395-401.
17. Salamon G, Lazorthes G. Tumours of the basal ganglia: An angiographic study. Neuroradiology 1971;2:80-9.
18. Smith S, Kozin ED, Kanumuri VV, Barber SR, Backous D, Nogueira JF, *et al*. Initial experience with 3- dimensional exoscope-assisted transmastoid and lateral skull base surgery. Otolaryngol Head Neck Surg 2019;160:364-7.
19. Takahashi S, Toda M, Nishimoto M, Ishihara E, Miwa T, Akiyama T, *et al*. Pros and cons of using ORBEYE(TM) for microneurosurgery. Clin Neurol Neurosurg 2018;174:57-62.
20. Yang Z, Zhu T, Fan Z, Song J. Surgical resection of a third ventricle nongerminomatous germ cell tumor: Two-dimensional operative video. World Neurosurg 2022;163:1.
21. Yaşargil MG. A legacy of microneurosurgery: Memoirs, lessons, and axioms. Neurosurgery 1999;45:1025-92.

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