

Frame-Based Stereotactic Surgery for a Deep-Seated Brain Cavernoma: A Case Report and Technical Video

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Case Report

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Abstract

Background

Cerebral cavernomas are the second most common vascular malformation of the central nervous system. While microsurgical excision is standard for accessible symptomatic lesions, stereotactic radiosurgery (SRS) is preferred for deep-seated or inaccessible cavernomas due to the higher complication risk of open resection, despite carrying its own risks of delayed hemorrhage and radiation-induced injury. Frame-based stereotactic surgical excision may combine the targeting precision of SRS with the immediate efficacy of surgical resection while avoiding radiation exposure.

Case Presentation:

A 25-year-old female presented with a history of headache, photophobia, blurred vision, and intermittent vomiting. Examination revealed left lateral gaze limitation and bilateral papilledema. MRI demonstrated a 15×20×24 mm intra-axial lesion in the left thalamic region extending to the left cerebral peduncle, causing obstructive hydrocephalus, initially favored as glioma. After endoscopic third ventriculostomy and an inconclusive endoscopic biopsy, stereotactic partial excision was performed using a novel 3D-printed stereotactic frame. Intraoperative findings and histopathology confirmed cavernoma rather than glioma. The procedure was uneventful, with no hemorrhage on postoperative imaging, and the patient was discharged on postoperative day two with an intact neurological examination.

Conclusion

Frame-based stereotactic surgical excision using this novel low-cost stereotactic system enabled safe, precise debulking of a deep-seated, rare thalamic-peduncular cavernoma, achieving diagnostic confirmation and symptomatic mass-effect reduction without complications. This approach may offer a viable alternative for deep, eloquently located cavernomas where open microsurgery carries excessive risk and SRS risks incomplete treatment and radiation side effects, warranting further evaluation in larger case series.

Background

Cerebral cavernomas are considered the second most common vascular malformation in the central nervous system, composed of thin-walled dilated capillaries with no intervening brain tissue. The majority of cavernomas are located supratentorial, while in the brainstem, pons is the most common site. They occur infrequently, with an incidence rate of less than 1%, of which 40% are incidentally discovered. When symptomatic, patients present with seizures, hemorrhage, mass effect or neurological deficits depending on the location [1–3].

Management of cavernomas ranges from observation and medical management, reserved for asymptomatic patients, to microsurgical approaches and minimally invasive techniques like stereotactic radiosurgery (SRS) [1]. While microsurgical excision is the standard treatment for symptomatic, easily accessible cavernomas, SRS represents a better option for deep-seated or inaccessible ones, since they carry a greater complication risk [1, 4]. Although SRS has comparable efficacy to microsurgery for removal of inaccessible deep cavernomas, some studies reported it carries a considerable risk of bleeding and radiation-induced adverse events, especially considering the proximity to sensitive structures like the brainstem or basal ganglia [4, 5].

In this study, we propose the utilization of stereotaxy for surgical excision of cavernoma which combines the localization and accuracy advantages of SRS in dealing with deep-seated cavernomas with the efficacy of surgical excision, while avoiding radiation exposure and increased risk of bleeding. This case study reports the successful use of frame-based stereotactic partial surgical excision for the treatment of a deep-seated cavernoma.

Case Presentation

A 25-year-old female patient was referred to our neurosurgery outpatient clinic (OPC) presenting with a one-month history of headaches, and photophobia with blurring of vision and intermittent vomiting for three weeks. On neurological examination, GCS was 15 with intact sensory and motor examination apart from squinting in the left eye. Ocular examination revealed a visual acuity of 6/9 in both eyes, mild limitation in the lateral gaze of the left eye, and papilledema grade II on right and grade III on the left eye on fundus examination. Magnetic Resonance Imaging (MRI) was done revealing an intra-axial space-occupying lesion in the left thalamic region extending into the left cerebral peduncle of the brainstem (Fig. 1A). The lesion displayed intermediate signal intensity on T1, T2 and FLAIR sequences and measured 15×20×24 mm with surrounding edema. It exerted mass effect upon aqueduct of Sylvius and third ventricle resulting in moderate upstream hydrocephalus. The MRI report suggested this mass to be a glioma with hydrocephalus. Medical treatment was initiated in the form of acetazolamide, K syrup, prednisolone, and paracetamol for two weeks. The patient then underwent endoscopic third ventriculostomy (ETV) and endoscopic biopsy which was inconclusive. Accordingly, a decision of stereotactic partial excision was made to debulk the tumor, decreasing its mass effect on the aqueduct and third ventricle, and analyze the biopsy. Stereotactic targeting was performed using a novel 3D-printed frame [6] which is first re-zeroed to (0,0,0) reference point then the Cartesian coordinates of the lesion were calculated directly from the MRI and transferred mechanically to the frame by sequentially adjusting the Y-bar, X-cylinder, and quarter arc to the corresponding Z, Y, and X values, with the declination and azimuth angles set to define the trajectory. The Nashold biopsy needle was then advanced, through a frontal trajectory, to the pre-calculated depth to the target lesion. Since the MRI protocol for surgical planning was more detailed, it displayed the characteristic popcorn appearance, a classic imaging hallmark suggesting the lesion was cavernoma rather than glioma (Fig. 1B). Histopathological examination of the specimen revealed dilated vascular spaces (cavernous), lined by flat endothelial cells and filled with blood. There was no evidence of atypia, necrosis or vascular

proliferation confirming the diagnosis of cavernoma. There were no intraoperative complications and postoperative course was uneventful. Follow-up CT demonstrated the partially excised cavernoma with no evidence of hemorrhage (Fig. 1C). The patient was discharged two days after surgery ambulant and afebrile with intact motor and sensory examination. The patient is continuing follow up in our OPC to monitor for hemorrhage and will undergo stereotactic radiosurgery to remove the remnant if deemed necessary.

Discussion

Our case highlights the potential role of stereotactic surgical excision as an approach that combines the advantages of microsurgical resection and stereotactic radiosurgery. This strategy may provide the benefits of both techniques while avoiding radiation-related complications, making it a promising option for deep-seated cavernomas.

The location of cavernoma in our patient is considered one of the rarest positions reported in literature. In a review gathering percentages for cavernoma locations, the thalamic position was not explicitly mentioned as a separate item; however, it is closest to the third ventricle, forming its lateral walls, which was reported as 0.7% of supratentorial locations [7]. Additionally, it also extends to the brainstem making surgical management particularly challenging because of its deep location and proximity to eloquent structures.

MRI is considered the most sensitive radiological tool to diagnose cavernomas. Although the popcorn appearance is the classic finding on MRI, cavernomas have been divided into four MRI-based types according to hemorrhage inside the lesion. The initial MRI most likely demonstrated type III but since it is isointense and in a rare location, the differential diagnosis was with glioma. Later during preparation for stereotactic excision, with a more sensitive modality of MRI, the popcorn sign appeared. This discrepancy could be due to the use of a more accurate modality, or be attributed to the dynamic nature of lesion where a change in the hemorrhage pattern inside the cavernoma has occurred since there was a time period of one month and an additional procedure done between the first and second MRIs [7].

The use of the Abdelwahab frame in this case was particularly advantageous given the lesion's depth and proximity to critical structures. Because the lesion abutted the aqueduct of Sylvius and extended into the cerebral peduncle, a wide margin for targeting error was not acceptable, especially in a patient already compromised by raised intracranial pressure and papilledema. The frame's physically reachable, re-zeroable reference point allowed the target and fiducial markers to be visualized within the same MRI study, avoiding the registration errors introduced by CT–MRI fusion and ensuring the trajectory reached the lesion without deviation into the adjacent thalamus, peduncle, or ventricular system. Its submillimetric accuracy in prior phantom validation (mean target registration error of 0.19 ± 0.07 mm) supported confidence in approaching a lesion this small and deep, which freehand navigation alone would have struggled to target reliably. The system's simplified setup, previously benchmarked at under

10 minutes in phantom testing, and its independence from costly fusion software further made it a practical choice in this resource-limited setting [6].

For our patient, only partial excision was planned and performed since the diagnosis was uncertain so a biopsy was needed for confirmation; hence the potential need for a follow up SRS to remove the remnant preventing lesion progression or hemorrhage in the long term. However, given the procedure's success with no intra or postoperative complications, intact motor and sensory examination and short hospital stay, this procedure could potentially be used to fully excise deeply-seated cavernomas. Prospective case series evaluating this technique should be done on small symptomatic and deep cavernomas to investigate the success of total excision, long-term outcomes and if there would be certain criteria regarding the lesion to use this technique.

Conclusion

This case illustrates the successful use of a novel, low-cost, frame-based stereotactic system for the partial excision of a rare, deep-seated thalamic-peduncular cavernoma initially mistaken for a glioma. By combining the localization precision typically associated with stereotactic radiosurgery with the immediate mass-effect reduction and diagnostic certainty of surgical excision, this technique avoided both the radiation-related risks of SRS and the elevated morbidity of open microsurgical approaches to deep, eloquent lesions. The absence of intraoperative or postoperative complications, together with the patient's rapid recovery and intact neurological status, supports the feasibility and safety of this approach for carefully selected deep-seated cavernomas. Given that only partial debulking was performed pending histopathological confirmation, further studies — ideally on small, symptomatic, deep-seated cavernomas — are warranted to evaluate the safety and efficacy of complete stereotactic excision, define appropriate patient selection criteria, and establish long-term outcomes.

Abbreviations

SRS

Stereotactic radiosurgery

OPC

Outpatient clinic

GCS

Glasgow Coma Scale

MRI

Magnetic resonance imaging

CT

Computed tomography

Declarations

Consent to participate: An informed consent has been obtained from the patient to write about the case and there is no content in this paper that may disclose the identity or break the confidentiality of the patient

Informed consent to publish: Consent for publication of medical information and accompanying images was obtained from the patient and all authors on the manuscript

Availability of data and materials: Not applicable owing to the study design

Competing interests: The authors declare that they have no competing interests. The stereotactic frame is patent pending.

Dual publication: The authors declare that no information in this study has been published elsewhere

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Author Contribution

Y.M. gathered information and wrote the manuscript; F.A.A. helped in gathering information and writing. M.A.K. supervised the procedure. A.A. is the supervisor and the surgeon who managed the patient.

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Figures

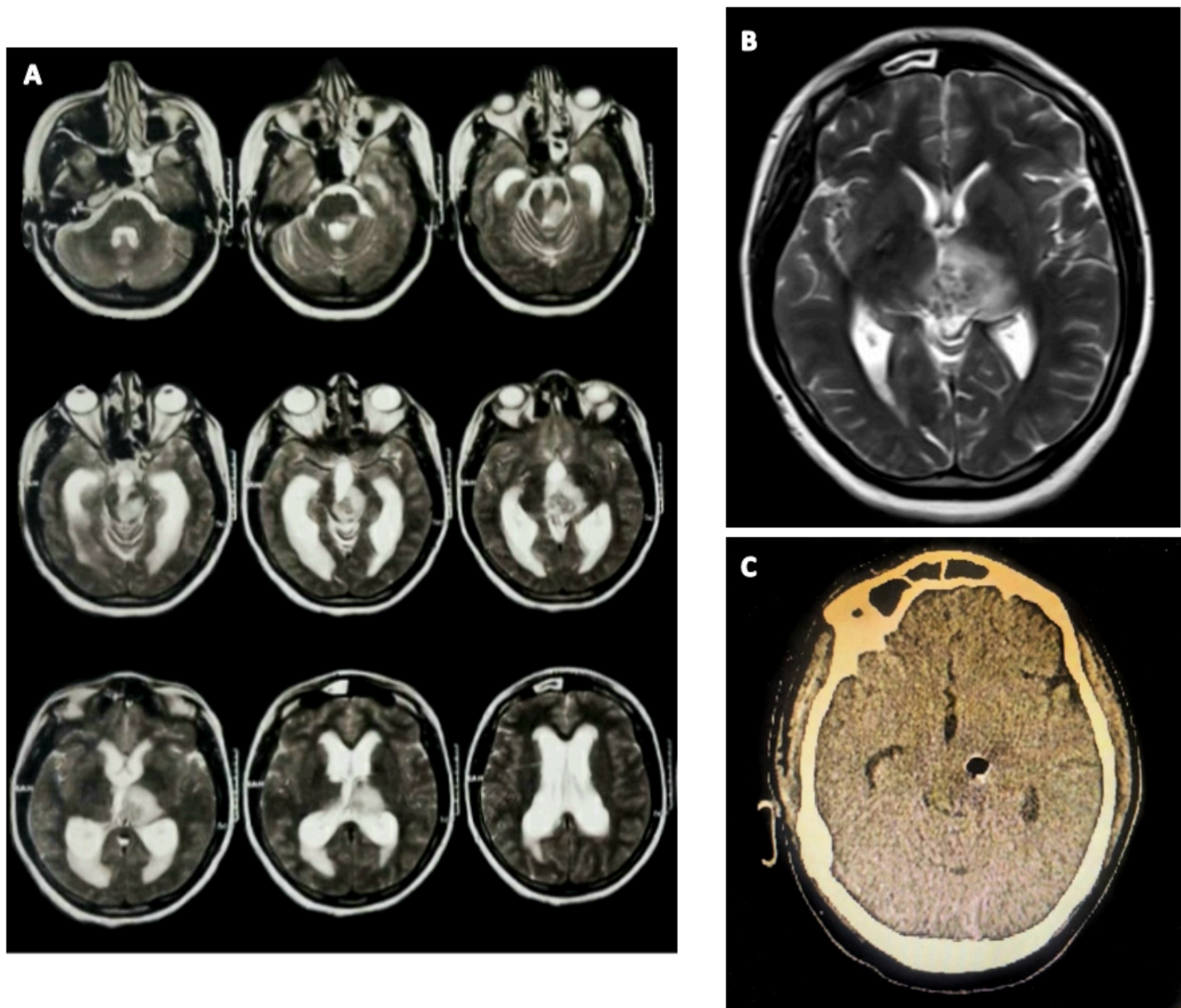


Figure 1

pre and post procedural imaging of the lesion

A: Pre-operative axial brain MRI, T2 sequence, showing a space-occupying lesion in the thalamus, extending to the cerebral peduncle

B: Intraoperative axial brain MRI, T2 sequence, showing the popcorn appearance; a hallmark for cavernoma

C: Post-operative axial brain CT showing partial excision of the mass (debulking)

Supplementary Files

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- [IMG2622.mov](#)