Published online: 2020-12-15

Transcortical Approach to Deep-Seated Intraventricular and Intra-axial Tumors Using a Tubular Retractor System: A Technical Note and Review of the Literature

Mohamed Okasha[1] Georgia Ineson[2] Jonathan Pesic-Smith[1] Surash Surash[1]

[1] Department of Neurosurgery, Royal Victoria Infirmary, Newcastle Upon Tyne, United Kingdom of Great Britain and Northern Ireland
[2] Medical School, Newcastle University, Newcastle upon Tyne, Tyne and Wear, United Kingdom of Great Britain and Northern Ireland

Address for correspondence Mohamed Okasha, PhD, Department of Neurosurgery, Royal Victoria Infirmary, Queen Victoria Road, Newcastle Upon Tyne NE1 4LP, United Kingdom of Great Britain and Northern Ireland (e-mail: okasha_neuro@yahoo.com).

J Neurol Surg A

Abstract

Background Retraction of white matter overlying a brain lesion can be difficult without causing significant trauma especially when using traditional methods of bladed retractors. These conventional retractors can produce regions of focal pressure resulting in contusions and areas of infarct.

Methods In this article, we present a retrospective case series of six patients with deep-seated intraventricular and intra-axial tumors that were approached using a ViewSite Brain Access System (tubular retractor). The authors describe a unique method of creating a pathway using a dilated glove. We shall also review the relevant literature that reports this type of surgery. Cases included three cases with third ventricular colloid cysts, one case of a third ventricular arachnoid cyst, one case with a lateral ventricular neurocytoma, and a case with a deeply seated intra-axial metastatic tumor.

Results Gross total resection was achieved in five cases with small residual in the central neurocytoma operation, with no documented neurological deficit in any case. One case had persistent memory problems and one case had continuing decline from the metastatic disease.

Conclusion The introduction of tubular-shaped retractor systems has offered the advantage of reducing retraction pressures and distributing any remaining force in a more even and larger distributed area, thus reducing the risk of previous associated morbidity while also permitting great visualization of the target lesion.

Keywords

- tubular retractor
- intraventricular tumors
- colloid cyst
- minimal invasive surgery
- balloon dilatation

Introduction

The transcortical approach to intraventricular and deeply seated intra-axial lesions has been developed over the course of many years. McKissock recommended removing a conical section of the brain to gain access to colloid cysts.[1] Since the invention of the surgical microscope, this has evolved into linear corticotomies and placement of retractors, allowing for improved visualization of the surgical fields.[2] Traditional retractor blades can lead to reduced perfusion and injury to the surrounding brain.[3] Although endoscopic techniques have been developed, there are cases that require open surgery. Various types of tubular retractors have been used since the 1980s to provide access with deep brain lesions.[4–7]

In this report, we retrospectively present a case series of six patients with intraventricular or intra-axial brain lesions

received
October 20, 2019
accepted
December 20, 2019

DOI https://doi.org/10.1055/s-0040-1719025.
ISSN 2193-6315.

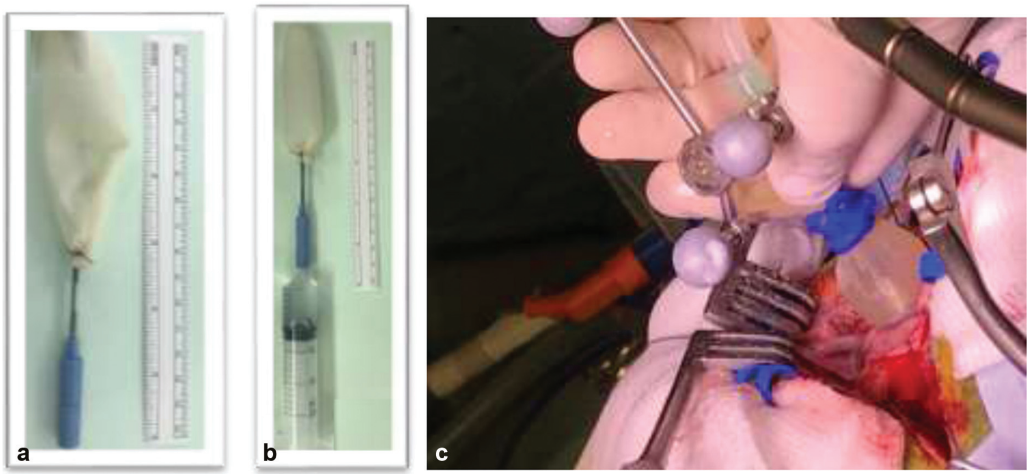

Fig. 1 Technical steps. Demonstration of the technique: (a) setting up of the cannula attached to the rubber glove, (b) then inflated with saline to dilate the surgical corridor, and (c) neuronavigation-guided insertion of the Dandy cannula and dilation of the track.

who underwent surgical resection utilizing a transcortical tubular approach. We shall also report our unique dilatation method by using a dilated glove to create a pathway to the lesion. And finally, we shall evaluate the utility and safety of this technique from the known literature.

Methods

We present a retrospective case series of six patients who underwent minimally invasive craniotomy for removal of intraventricular and intraparenchymal lesions using tubular retractors at the Royal Victoria Infirmary, Newcastle upon Tyne Hospital, in the period from 2016 to 2019 (a single surgeon experience). All the patients underwent preoperative magnetic resonance imaging (MRI) with neuronavigation protocols. Early postoperative computerized tomography (CT) (24 hours postoperative) and a 3-month MRI were performed for all the patients with clinical review.

Technical Note

The retractor consists of a transparent outer working channel and inner introducer (ViewSite Brain Access System), the port being 12 mm in diameter and 7 cm in length. All patients were positioned supine and fixed in a three-pin Mayfield clamp. Preoperatively, a surgical trajectory was planned in all cases using stereotactic image-guided neuronavigation to best avoid eloquent areas of white matter. A mini-craniotomy was performed in all cases (<3 cm).

A linear small corticotomy was made using bipolar cautery to best match the width of the chosen retractor. The direction of insertion was first confirmed using frameless neuronavigation by inserting a calibrated Dandy cannula to the planned depth of where the lesion was. Dilatation of the surgical tract was then achieved using a technique of dilating an elastic balloon (part of a glove was used) with 20 mL of warm saline for 60 seconds (►**Fig. 1**). The purpose of this was to displace neighboring tracts rather than cut them in the process of retraction. The retractor system was then inserted and once the location was visualized, the inner introducer was removed (►**Fig. 2**). The tubular retractor was held in this position by a flexible arm of the Greenberg retractor system. This allowed excellent visualization of the lesion (►**Fig. 3**). Standard microsurgical instruments were used to deal with the lesion. Following hemostasis, the retractor was removed and the wound was closed in a standard fashion.

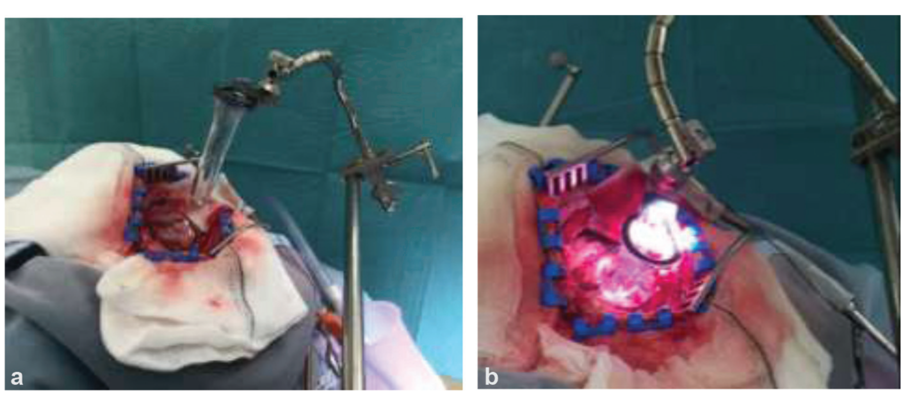

Fig. 2 Technical steps. (a) Setup of the tubular retractor and (b) insertion of the retractor (attached to a Greenberg retractor arm).

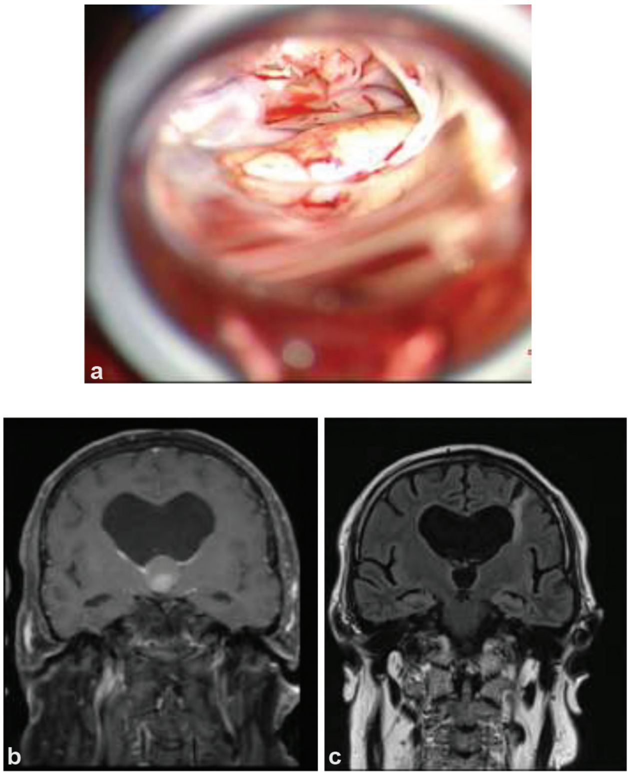

Fig. 3 (a) Microscopic view through the tubular retractor following fenestration of the cyst, with (b) preoperative and (c) postoperative magnetic resonance images.

Results

Six patients, age ranging from 33 to 73 (average 56.7) years, were operated on using the minimally invasive tubular retractor technique. Three cases with colloid cyst of the third ventricle had total resection, one case with right lateral ventricular central neurocytoma had subtotal resection, and one case with a right-sided deeply seated frontoparietal adenocarcinoma metastasis had total macroscopic resection. Cases are represented in ►**Table 1**. Follow-up period varied from 1 to 6 months with good early postoperative recovery and improved headache and absence of any neurological deterioration associated from using the tubular retractor or from removal of the lesions. Three-month postoperative MRI showed healing of the surgical corridor with minimal retraction effect. These cases represent a single surgeon's experience at our unit.

Discussion

Retraction of the white matter overlying a brain lesion can be difficult without causing any significant trauma, especially when using traditional methods of bladed retractors. Retraction-associated injury is a known complication in neurosurgery and can cause seizure, neurologic deficits, brain edema, and worsened neurologic outcome.[3,8]

These conventional retractors can produce regions of focal pressure resulting in contusions and areas of infarct, with the risk of cutting fiber tracts on the approach to the lesion. The challenge for transcortical approaches is to allow good access and visualization while minimizing damage to the surrounding brain.

The use of an endoscope in intraventricular tumors provides excellent visualization; however, it does not allow for ambidextrous working. There is up to 62% cyst wall residuum and 0 to 10% recurrence rate in colloid cysts.[9] However, there is minimal brain injury with the endoscopic approach.

The introduction of tubular-shaped retractor systems has offered the advantage of reducing retraction pressures and distributing any remaining force in a more even and larger distributed area, thus reducing the risk of previous associated morbidity.

The tubular retractor we used was easy to insert and allowed for an even spread of retraction on the surrounding brain. The surgical exposure allowed excellent access to the lesion, which was removed with minimal difficulty, while not hampering the space for instruments. The operating port provides adequate amount of space for microsurgical instruments and bipolar cautery, which is vital as colloid cysts can adhere to surrounding important structures and vessels.

Literature Review

In a search of the literature, 18 relevant articles were identified and reviewed, which represent a total of 416 patients who underwent minimally invasive procedure with the use of different types of tubular retractor systems. Details of the articles, outcome, and complications of these studies are summarized in ►**Table 2**.

ViewSite Brain Access System

Although there is currently an assortment of commercially available tubular retractors or techniques in which surgical teams have modified preexisting equipment (e.g., syringes), the most frequently mentioned tubular retractor system in the current literature is the ViewSite Brain Access System (used in our cases) manufactured by Vycor Medical (Florida, United States).

The use of the ViewSite system has been reported by six authors in the resection of differing brain lesions, including deep intra-axial tumors and hemorrhage. The most frequently described lesion was glioma.[10–15] The ViewSite Brain Access System is a completely transparent assembly (including the introducer) allowing for continuous monitoring of the dissection corridor.[10]

Whereas some authors described the need to "dissect a few centimeters of white matter to accommodate the retractor,"[11,13] Recinos et al argued that the "elliptical shape of the retractor split the deep matter thus negating the need for white matter resection."[12] However, Otani et al used brain spatulas alongside the system to aid dissection down onto the target lesion.[15]

The outcomes assessed by all the authors included a comparison between pre- and post-operative imaging, neurological outcomes, extent of resection, and complication occurrence. All the authors agreed that the use of tubular retractors, especially in the resection of deep-seated lesions, was a safe and effective surgical approach.[10–15]

Table 1 Demographics, presentation, diagnosis, and outcome of the cases

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Age	63 y	48 y	71 y	33 y	73 y	52 y
Gender	M	M	F	M	M	F
Presentation	Acute on top of chronic headache	Chronic headache and memory	Seizure, no headache	Sudden onset headache	Seizures	Headache and diplopia
Diagnosis	Colloid cyst + hydrocephalus	Colloid cyst	Colloid cyst	Lateral ventricle. G2 central neurocytoma	Deep metastasis (colorectal adenocarcinoma)	Right lateral ventricular cyst with unilateral ventriculomegaly
Lesion size	22 × 20 × 20 mm	14 × 16 × 10 mm	6 × 6 × 7 mm	33 × 18 × 20 mm	40 × 48 × 33 mm	11 × 12 × 17 mm
Location	3rd ventricle	3rd ventricle	3rd ventricle	Right lateral ventricle	Right parietal	3rd ventricle
Approach side	Left frontal	Right frontal	Left frontal	Right frontal	Right frontal	Right frontal
EVD insertion	yes	No	No	yes	no	no
HDU admission	2 d	No	Yes	yes	yes	yes
Extent of resection	Total	Total	Total	Subtotal	Total	Total
Neuropsychology	improved	improved	static	Deteriorated memory	n/a	none
Early post-op complications	Electrolyte imbalance (improved)	None	None	None	Deterioration, rated secondary to malignancy	None
6 mo post-op review complications/symptoms	Memory decline	None	Reviewed for recurrent stroke, no seizures	None	Deterioration, rated secondary to primary tumor	None

Abbreviations: EVD, external ventricular drain; HDU, high-dependency unit.

Table 2 Literature review of the minimal invasive tubular techniques

Device	Author	No. of cases	Diagnoses	Outcomes and complications
VBAS	Raza et al[11]	9	Subacute infarction Toxoplasmosis Colloid cyst Lymphoma Subependymoma Papillary tumor Anaplastic astrocytoma Dysembryoplastic neuroepithelial tumor	White matter damage along surgical trajectory in 1 patient on FLAIR/T2 magnetic resonance images
VBAS	Herrera et al[10]	16	Intracerebral hematoma Intracerebral cyst Metastases Glioma Gangliogliomas	Preoperative goals met, no reported complications
VBAS	White et al[14]	3	High-grade glioma Cavernoma	Preoperative goals met, “typical postoperative resection cavity”
VBAS	Recinos et al[12]	4	Papillary tumor Low-grade astrocytoma Dysembryoplastic neuroepithelial tumor Low-grade glioma	Preoperative goals met, changes beyond surgical bed on FLAIR/T2/DWI magnetic resonance images in 1 patient
VBAS	Hong et al[13]	20	Metastases Glioma Meningioma Neurocytoma Radiation necrosis Primitive neuroectodermal tumor Hemangioblastoma	Gross total resection achieved in 70%, “minimal residual edema”, “rates of postoperative complications were low”
VBAS	Otani et al[15]	9	Central neurocytoma Glioblastoma multiforme Metastases Cavernoma	Gross total resection achieved in 44.4%, no reported complications, mean post-op DWI high signal was 3.68 ± 0.80 cm^3
VBAS and BP	Eichberg et al[18]	10	Colloid cysts	Gross total resection achieved in all patients, early neurologic deficit occurred in 10% and permanent in 0%
BP	Norton et al[27]	28	Intracranial hemorrhage Brain tumor	Reduction in length of stay was seen in the group in which BrainPath was used
BP	Mampre et al[17]	15	Metastases Cavernoma Hemangioblastoma	Post-op the median lesion volume was 0 cm, no post-operative complications
BP	Iyer et al[16]	14	High-grade glioma	Gross resection was achieved in 40%, 1 patient suffered from progressive weakness
BP	Scranton et al[26]	2	Cavernoma	Using transulcal parafascicular with excellent results
SP	Singh et al[19]	62	Ventricular tumors Colloid cysts Deep-seated gliomas Basal ganglia hemorrhages	No operative site hematomas or contusions, 3 patients had additional neurological deficits post-operatively
SP	Almubarak et al[20]	9	Glioblastoma multiforme Gliosarcoma Toxoplasmosis	Surgical goals achieved in 8 patients
METRDT	Bander et al[24]	20	NSCLC metastases Breast metastases Meningioma Cavernoma Glioblastoma multiforme	Gross total resection achieved in 75%, average post-operative FLAIR signal on magnetic resonance imaging was 43.75–41.61; this was not statistically significant from the pre-operative signal

(*Continued*)

Table 2 (*Continued*)

Device	Author	No. of cases	Diagnoses	Outcomes and complications
			Ependymoma Granular cell tumor Toxoplasmosis Craniopharyngioma	
METRDT	Ratre et al[23]	100	Astrocytoma Meningiomas Colloid cysts Metastases Primitive neuroectodermal tumor Neurocytoma Ependymoma	No infarction or infection, brain contusions occurred in 4 patients
METRDT	Almenawer et al[21]	30	Pilocytic astrocytoma Metastases Epidermoid cyst Central neurocytoma Astroblastoma Craniopharyngioma Glioblastoma multiforme Meningioma Subependymal astrocytoma Anaplastic oligodendroglioma Cavernoma Ependymoma	70% had gross total resection
METRDT	Gassie et al[28]	50	Not specified	70% surgical resection and 30% excisional biopsy
METRDT	Greenfield et al[7]	10	NSCLC metastases Breast metastases Meningioma Cavernoma Glioblastoma multiforme	Radiographic gross total resection achieved in all patients; 1 patient had transient worsening of preoperatively existing Wernicke's aphasia, no other intra- or post-operative complications
METRDT	Newman and Engh[22]	8	NSCLC metastases Meningioma Colloid cyst Esophageal adenocarcinoma metastases Neurofibroma Clear cell meningioma	All patients underwent total lesional resection without new neurological deficits
Polyester film	Ogura et al[25]	11	Metastases Hematoma Cavernoma Lymphoma Glioblastoma multiforme	Total removal in 4 cases, subtotal removal in 4 cases, partial removal in 1 case, and biopsy in 2 cases

Abbreviations: BP, BrainPath; DWI, diffusion-weighted imaging; FLAIR, fluid-attenuated inversion recovery;GBM, glioblastoma; METRDT, Minimal Exposure Tubular Retractors and Dilatable Tubes; NSCLC: non–small cell lung carcinoma; SP, Syringe Ports; VBAS: ViewSite Brain Access System.

Herrera et al. observed that the even force distributed across retracted brain tissues when using ViewSite Brain Access System reduced the rate of retraction-related complications.[10] This observation was supported by Recinos et al, who felt that the use of tubular retractors was advantageous in pediatric populations to curtail the risk of long-term sequelae associated with white matter damage.[12]

BrainPath

The second of the current commercially available tubular retractor systems is the NICO BrainPath (Indianapolis, United States) The BrainPath's obturator has a minimally disruptive tip that is designed to minimize tissue damage by displacing brain tissue during advancement to the target lesion. The sheath remains in the brain after the obturator is removed to serve as a protective corridor for surgeons.

Preoperative trajectory planning was performed by all the three authors with the aid of frameless neuronavigation.[16–18]

Some authors concluded that BrainPath retractors were associated with minimal morbidity while still achieving extensive resection of lesions (►**Table 2**).[16,17]

Syringe Ports

Because the aforementioned commercially available tubular retractor systems are very costly, more cost-effective alternative techniques utilizing preexisting products have also been described in the literature. Both Singh et al and Almubarak et al developed a novel retractor port system fashioned from disposable syringes. The nature of the syringe ports means they are both easily customizable and readily available and sizing could be altered to best accommodate the extent and depth of the lesion.[19,20]

A simple 10-mL syringe was utilized as a tubular retractor by cutting the mouth of the syringe with a sharp knife. The syringe was then introduced under neuronavigation to the deepest part of the lesion so that resection could be undertaken.

Minimal Exposure Tubular Retractors and Dilatable Tubes

The Minimal Exposure Tubular Retractors (METRx) System (Medtronic, Minnesota, United States) is a series of dilators and tubes designed to be used primarily for spinal procedures.

Five authors reported their observations from utilizing the METRx system, adapted for cranial usage.[7,21–24]

Almenawer et al described the main advantage of this technique being the “gradual dilation of the surrounding brain tissue” compared with more conventional tubular retractors in which “a certain amount of tissue injury is required to accommodate the tubes during the single-entry technique.” The advantage over other port techniques is that it allows for variation in the size of operating corridors, which are dictated by the needs of the tumor.[21,22]

Conclusion

The authors report a series of six cases operated on between 2017 and 2019 using a ViewSite tubular retractor. In all but one cases, complete removal of lesion was achieved, with no morbidity associated with either tumor removal or the transcortical approach.

This review has identified not only alternatives to the ViewSite system but also different approaches to achieve dissection prior to inserting the tubular retractor.

This article presents a novel approach to dilating the tract by using neuronavigation and employing a balloon dilation system by expanding a cut finger from a glove with warm saline to atraumatically expand the corridor without tract injury. In our series, excellent visualization of the lesions was achieved, with good clearance and no retraction-associated morbidity. This article therefore supports the use of minimal access transcortical surgery as a safe and effective alternative to both endoscopic and traditional methods.

Conflict of Interest
None declared.

References

1 McKISSOCK W. The surgical treatment of colloid cyst of the third ventricle; a report based upon twenty-one personal cases. Brain 1951;74(01):1–9

2 Ellenbogen RG. Transcortical surgery for lateral ventricular tumors. Neurosurg Focus 2001;10(06):E2

3 Zhong J, Dujovny M, Perlin AR, Perez-Arjona E, Park HK, Diaz FG. Brain retraction injury. Neurol Res 2003;25(08):831–838

4 Kelly PJ, Kall BA, Goerss SJ. Computer-interactive stereotactic resection of deep-seated and centrally located intraaxial brain lesions. Appl Neurophysiol 1987;50(1–6):107–113

5 Kelly PJ, Goerss SJ, Kall BA. The stereotaxic retractor in computer-assisted stereotaxic microsurgery. Technical note. J Neurosurg 1988;69(02):301–306

6 Kelly PJ. Future perspectives in stereotactic neurosurgery: stereotactic microsurgical removal of deep brain tumors. J Neurosurg Sci 1989;33(01):149–154

7 Greenfield JP, Cobb WS, Tsouris AJ, Schwartz TH. Stereotactic minimally invasive tubular retractor system for deep brain lesions. Neurosurgery 2008;63(04, Suppl 2):334–339, discussion 339–340

8 Harada S, Nakamura T. Retraction induced brain edema. Acta Neurochir Suppl (Wien) 1994;60:449–451

9 Cohen-Gadol AA. Minitubular transcortical microsurgical approach for gross total resection of third ventricular colloid cysts: technique and assessment. World Neurosurg 2013;79(01):207.e7–207.e10

10 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. Surg Technol Int 2010; 19:47–50

11 Raza SM, Recinos PF, Avendano J, Adams H, Jallo GI, Quinones-Hinojosa A. Minimally invasive trans-portal resection of deep intracranial lesions. Minim Invasive Neurosurg 2011;54(01): 5–11

12 Recinos PF, Raza SM, Jallo GI, Recinos VR. Use of a minimally invasive tubular retraction system for deep-seated tumors in pediatric patients. J Neurosurg Pediatr 2011;7(05):516–521

13 Hong CS, Prevedello DM, Elder JB. Comparison of endoscope-versus microscope-assisted resection of deep-seated intracranial lesions using a minimally invasive port retractor system. J Neurosurg 2016;124(03):799–810

14 White T, Chakraborty S, Lall R, Fanous AA, Boockvar J, Langer DJ. Frameless stereotactic insertion of ViewSite brain access system with microscope-mounted tracking device for resection of deep brain lesions: technical report. Cureus 2017;9(02):e1012

15 Otani Y, Kurozumi K, Ishida J, et al. Combination of the tubular retractor and brain spatulas provides an adequate operative field in surgery for deep-seated lesions: case series and technical note. Surg Neurol Int 2018;9:220

16 Iyer R, Chaichana KL. Minimally invasive resection of deep-seated high-grade gliomas using tubular retractors and exoscopic visualization. J Neurol Surg A Cent Eur Neurosurg 2018;79(04): 330–336

17 Mampre D, Bechtle A, Chaichana KL. Minimally invasive resection of intra-axial posterior fossa tumors using tubular retractors. World Neurosurg 2018;119:e1016–e1020

18 Eichberg DG, Buttrick SS, Sharaf JM, et al. Use of tubular retractor for resection of colloid cysts: single surgeon experience and review of the literature. Oper Neurosurg (Hagerstown) 2019;16 (05):571–579

19 Singh H, Patir R, Vaishya S, Miglani R, Kaur A. Syringe port: a convenient, safe, and cost-effective tubular retractor for transportal removal of deep-seated lesions of the brain. World Neurosurg 2018;114:117–120

20 Almubarak AO, Alobaid A, Qoqandi O, Bafaquh M. Minimally invasive brain port approach for accessing deep-seated lesions using simple syringe. World Neurosurg 2018;117:54–61

21 Almenawer SA, Crevier L, Murty N, Kassam A, Reddy K. Minimal access to deep intracranial lesions using a serial dilatation technique: case-series and review of brain tubular retractor systems. Neurosurg Rev 2013;36(02):321–329, discussion 329–330

22 Newman WC, Engh JA. Stereotactic-guided dilatable endoscopic port surgery for deep-seated brain tumors: technical report with comparative case series analysis. World Neurosurg 2019;125: e812–e819

23 Ratre S, Yadav YR, Parihar VS, Kher Y. Microendoscopic removal of deep-seated brain tumors using tubular retraction system. J Neurol Surg A Cent Eur Neurosurg 2016;77(04):312–320
24 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. J Neurosurg 2016;124(04):1053–1060
25 Ogura K, Tachibana E, Aoshima C, Sumitomo M. New microsurgical technique for intraparenchymal lesions of the brain: transcylinder approach. Acta Neurochir (Wien) 2006;148(07):779–785, discussion 785
26 Scranton RA, Fung SH, Britz GW. Transulcal parafascicular minimally invasive approach to deep and subcortical cavernomas: technical note. J Neurosurg 2016;125(06):1360–1366
27 Norton SP, Dickerson EM, Kulwin CG, Shah MV. Technology that achieves the triple aim: an economic analysis of the BrainPath™ approach in neurosurgery. Clinicoecon Outcomes Res 2017; 9:519–523
28 Gassie K, Wijesekera O, Chaichana KL. Minimally invasive tubular retractor-assisted biopsy and resection of subcortical intra-axial gliomas and other neoplasms. J Neurosurg Sci 2018;62(06): 682–689