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

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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.

Keywords
► tubular retractor
► intraventricular tumors
► colloid cyst
► minimal invasive surgery
► balloon dilatation

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.

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. 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. Traditional retractor blades can lead to reduced perfusion and injury to the surrounding brain. 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.

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

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**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.

**Fig. 2** Technical steps. (a) Setup of the tubular retractor and (b) insertion of the retractor (attached to a Greenberg retractor arm).
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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. 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. The ViewSite Brain Access System is a completely transparent assembly (including the introducer) allowing for continuous monitoring of the dissection corridor.

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

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

Abbreviations: EVD, external ventricular drain; HDU, high-dependency unit.
## Table 2 Literature review of the minimal invasive tubular techniques

<table>
<thead>
<tr>
<th>Device</th>
<th>Author</th>
<th>No. of cases</th>
<th>Diagnoses</th>
<th>Outcomes and complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBAS</td>
<td>Raza et al\textsuperscript{11}</td>
<td>9</td>
<td>Subacute infarction, Toxoplasmosis, Colloid cyst, Lymphoma, Subependymoma, Papillary tumor, Anaplastic astrocytoma, Dysembryoplastic neuroepithelial tumor</td>
<td>White matter damage along surgical trajectory in 1 patient on FLAIR/T2 magnetic resonance images</td>
</tr>
<tr>
<td>VBAS</td>
<td>Herrera et al\textsuperscript{10}</td>
<td>16</td>
<td>Intracerebral hematoma, Intracerebral cyst, Metastases, Glioma, Gangliogliomas</td>
<td>Preoperative goals met, no reported complications</td>
</tr>
<tr>
<td>VBAS</td>
<td>White et al\textsuperscript{14}</td>
<td>3</td>
<td>High-grade glioma, Cavernoma</td>
<td>Preoperative goals met, “typical postoperative resection cavity”</td>
</tr>
<tr>
<td>VBAS</td>
<td>Recinos et al\textsuperscript{12}</td>
<td>4</td>
<td>Papillary tumor, Low-grade astrocytoma, Dysembryoplastic neuroepithelial tumor, Low-grade glioma</td>
<td>Preoperative goals met, changes beyond surgical bed on FLAIR/T2/DWI magnetic resonance images in 1 patient</td>
</tr>
<tr>
<td>VBAS</td>
<td>Hong et al\textsuperscript{13}</td>
<td>20</td>
<td>Metastases, Glioma, Meningioma, Neurocytoma, Radiation necrosis, Primitive neuroectodermal tumor, Hemangioblastoma</td>
<td>Gross total resection achieved in 70%, “minimal residual edema”, “rates of postoperative complications were low”</td>
</tr>
<tr>
<td>VBAS</td>
<td>Otani et al\textsuperscript{15}</td>
<td>9</td>
<td>Central neurocytoma, Glioblastoma multiforme, Metastases, Cavernoma</td>
<td>Gross total resection achieved in 44.4%, no reported complications, mean post-op DWI high signal was $3.68 \pm 0.80 \text{ cm}^3$</td>
</tr>
<tr>
<td>VBAS and BP</td>
<td>Eichberg et al\textsuperscript{18}</td>
<td>10</td>
<td>Colloid cysts</td>
<td>Gross total resection achieved in all patients, early neurologic deficit occurred in 10% and permanent in 0%</td>
</tr>
<tr>
<td>BP</td>
<td>Norton et al\textsuperscript{27}</td>
<td>28</td>
<td>Intracranial hemorrhage, Brain tumor</td>
<td>Reduction in length of stay was seen in the group in which BrainPath was used</td>
</tr>
<tr>
<td>BP</td>
<td>Mampre et al\textsuperscript{17}</td>
<td>15</td>
<td>Metastases, Cavernoma, Hemangioblastoma</td>
<td>Post-op the median lesion volume was 0 cm, no post-operative complications</td>
</tr>
<tr>
<td>BP</td>
<td>Iyer et al\textsuperscript{16}</td>
<td>14</td>
<td>High-grade glioma</td>
<td>Gross resection was achieved in 40%, 1 patient suffered from progressive weakness</td>
</tr>
<tr>
<td>BP</td>
<td>Scranton et al\textsuperscript{26}</td>
<td>2</td>
<td>Cavernoma</td>
<td>Using transulcal parafascicular with excellent results</td>
</tr>
<tr>
<td>SP</td>
<td>Singh et al\textsuperscript{19}</td>
<td>62</td>
<td>Ventricular tumors, Colloid cysts, Deep-seated gliomas, Basal ganglia hemorrhages</td>
<td>No operative site hematomas or contusions, 3 patients had additional neurologic deficits post-operatively</td>
</tr>
<tr>
<td>SP</td>
<td>Almubarak et al\textsuperscript{20}</td>
<td>9</td>
<td>Glioblastoma multiforme, Gliosarcoma, Toxoplasmosis</td>
<td>Surgical goals achieved in 8 patients</td>
</tr>
<tr>
<td>METRDT</td>
<td>Bander et al\textsuperscript{24}</td>
<td>20</td>
<td>NSCLC metastases, Breast metastases, Meningioma, Cavernoma, Glioblastoma multiforme</td>
<td>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</td>
</tr>
</tbody>
</table>

(Continued)
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. 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.

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. Some authors concluded that BrainPath retractors were associated with minimal morbidity while still achieving extensive resection of lesions (Table 2).

### Syringe Ports

Because the aforementioned commercially available tubular retractor systems are very costly, more cost-effective alternative techniques utilizing preexisting products have also been explored. One such technique is the use of special syringe ports. These ports allow for the introduction of specialized substances into the surgical field, often serving to aid in retraction or to facilitate the delivery of therapeutic agents directly to the target area.

### Table 2 (Continued)

<table>
<thead>
<tr>
<th>Device</th>
<th>Author</th>
<th>No. of cases</th>
<th>Diagnoses</th>
<th>Outcomes and complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>METRDT</td>
<td>Ratre et al</td>
<td>100</td>
<td>Astrocytoma, Meningiomas, Metastases, Epidermoid cyst, Central neurocytoma, Astroblastoma, Craniopharyngioma, Glioblastoma multiforme, Meningioma, Subependymal astrocytoma, Anaplastic oligodendroglioma, Cavernoma, Ependymoma</td>
<td>No infarction or infection, brain contusions occurred in 4 patients</td>
</tr>
<tr>
<td>METRDT</td>
<td>Almenawer et al</td>
<td>30</td>
<td>Pilocytic astrocytoma, Metastases, Epidermoid cyst, Central neurocytoma, Astroblastoma, Craniopharyngioma, Glioblastoma multiforme, Meningioma, Subependymal astrocytoma, Anaplastic oligodendroglioma, Cavernoma, Ependymoma</td>
<td>70% had gross total resection</td>
</tr>
<tr>
<td>METRDT</td>
<td>Gassie et al</td>
<td>50</td>
<td>Not specified</td>
<td>70% surgical resection and 30% excisional biopsy</td>
</tr>
<tr>
<td>METRDT</td>
<td>Greenfield et al</td>
<td>10</td>
<td>NSCLC metastases, Breast metastases, Meningioma, Cavernoma, Glioblastoma multiforme</td>
<td>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</td>
</tr>
<tr>
<td>METRDT</td>
<td>Newman and Engh</td>
<td>8</td>
<td>NSCLC metastases, Meningioma, Colloid cyst, Esophageal adenocarcinoma metastases, Neurofibroma, Clear cell meningioma</td>
<td>All patients underwent total lesional resection without new neurological deficits</td>
</tr>
<tr>
<td>Polyester film</td>
<td>Ogura et al</td>
<td>11</td>
<td>Metastases, Hematoma, Cavernoma, Lymphoma, Glioblastoma multiforme</td>
<td>Total removal in 4 cases, subtotal removal in 4 cases, partial removal in 1 case, and biopsy in 2 cases</td>
</tr>
</tbody>
</table>

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.
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 case, 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.

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