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Case Report

Syringe Port System as a Tubular Retractor Technique for Brain Lesions: Case Series and Review of the Literature

Sistema dilatador-seringa como técnica de retração tubular para lesões cerebrais: Série de casos e revisão de literatura

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Abstract

Objective To describe a tubular retractor technique for brain lesions through a series of cases and to conduct a literature review on intracranial tubular retractors with emphasis on the syringe port system.

Materials and Methods We described four cases of lesions with an intraventricular component and different pathological patterns. The surgeries were performed between April, 2021 and July, 2022. The images were acquired through computed tomography (CT) and magnetic resonance imaging (MRI) scans and transferred to the Horos software, version 1.1.7. To make the tubular retractor, a 20-mL syringe and a 14-Fr/Ch, 30-mL/cc Foley probe were used. The syringe was sectioned according to the planned depth based on preoperative imaging. The syringe was the retractor itself, while the probe served as a means of dilating the path to the lesion.

Results Gross total resection was achieved in all cases, and the samples collected were satisfactory regarding the results of the anatomopathological study. All patients evolved without any additional deficits and with adequate postoperative image control.

Conclusion The syringe as a tubular retractor associated with the Foley probe as a surgical port dilator was useful, and it enabled the radical resection of intracranial

Keywords
- tubular retractors
- brain microsurgery
- deep-seated brain lesions
- syringe port system

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tumors related to the lateral ventricle, not limiting the use of auxiliary instruments, neither of microsurgical instruments; therefore, it is an affordable, secure, and inexpensive method.

Resumo

Objetivo Descrever uma técnica de retração tubular para lesões cerebrais por meio de uma série de casos e realizar uma revisão bibliográfica sobre retratores tubulares intracranianos com ênfase no sistema dilatador-seringa.
Materiais e Métodos Foram descritos quatro casos de lesões com componente intraventricular, com diferentes padrões patológicos. As cirurgias foram realizadas entre abril de 2021 e julho de 2022. As imagens foram adquiridas por tomografia computorizada (TC) e ressonância magnética (RM), e transferidas para o programa Horos, versão 1.1.7. Para fabricar o retrator tubular, foram utilizadas uma seringa de 20 mL e uma sonda Foley de 14Fr/Ch, 30mL/cc. A seringa foi seccionada de acordo com a profundidade planejada e com base na imagem pré-operatória. A seringa era o retrator em si, ao passo que a sonda servia como meio de dilatar o caminho para a lesão.
Resultados A ressecção total bruta foi alcançada em todos os casos, e as amostras recolhidas foram satisfatórias com relação aos resultados do estudo anatomopatológico. Todos os pacientes evoluíram sem quaisquer déficits adicionais e com controle de imagem pós-operatório adequado.
Conclusão A seringa como retrator tubular associado à sonda de Foley como dilatador cirúrgico foi útil e permitiu a ressecção radical de tumores intracranianos relacionados com o ventrículo lateral, e não limitou a utilização de instrumentos auxiliares, nem dos instrumentos microcirúrgicos, sendo assim um método acessível, seguro e pouco dispendioso.

Palavras-chave
► retratores tubulares
► microcirurgia cerebral
► lesões cerebrais profundas
► sistema de porta para seringas

Introduction

The advent of minimally invasive surgery in the twentieth century improved the extent of resection of deep brain lesions that were once difficult to manage. This was made possible by the introduction of several surgical techniques, such as microscopy and endoscopy in association with auxiliary tools, such as special retractors.

The use of tubular retractors in neurosurgery consists of placing a transparent tube in the brain parenchyma or in the vertebral column, which provides better visualization of the surgical site through both the endoscope and microscope.[1] The use of these techniques resulted in fewer intraoperative and postoperative complications when compared with the conventional techniques[2,3]

There are some commercial models of adjustable tubular brain retractors available, such as the Minimal Exposure Tubular Retractor (METRx, Medtronic, Memphis, TN, United States) system and ViewSite (Vycor Medical, Inc., Boca Raton, FL, United States). However, especially in lower- and middle-income countries, there is a need to develop techniques with lower costs, which could be done using resources already present in the local surgical environment. The aim of the present study was to describe a technical refinement of cerebral tubular retraction through a series of cases and to carry out a literature review on conventional intracranial tubular retractors and the syringe port method.

Materials and Methods

We described four cases of lesions with an intraventricular component and different pathological patterns. The surgeries were performed between April 2021 and July 2022. All patients consented to participate in the study. Brain magnetic resonance imaging (MRI) scans were acquired using a Discovery MR750w 3.0-T scanner (GE, Healthcare, Chicago, IL United States) with a 16-channel head coil and the following technical specifications: gradient – 40mT/m; matrix – 240 × 240 pixels; field of view – 240 × 240 mm; and cut thickness – 1 mm. The brain computed tomography (CT) scans were obtained using the Brilliance CT 64 System (Philips, Amsterdam, Netherlands with collimation of 20 × 0.625, 0.348 pitch, 512 × 512 matrix, 200-mm field of view, 140 kpV, 278 mA to 600 mA, and 1-mm thickness.

The image files were imported to the Horos software, version 1.1.7 (GNU General Public License, version 3), using the NeuroKeypoint[4] smart phone application to position the craniotomy in the planned location. Three-dimensional reconstructions of the sulci and gyrus along with the cortical veins were performed according to the previously described technique[5] for the exact definition of the corticectomy point. Intraoperative ultrasonography was used to assess any possible tumor residue. The Eximius neuronavigation system (Artis Tecnologia, Brasília, DF, Brazil) was used in cases 2 and 3.

During the operation, the head of the patient was fixed with Mayfield 3-point fixation. A small 3-cm craniotomy was performed, followed by opening of the dura mater and exposure of the brain parenchyma. The transsulcal route was chosen to minimize the volume of the transgressed cortex during the introduction of retraction. To make the tubular retractor, a 20-mL syringe with a diameter of 20 mm and a 14-Fr/Ch, 30-mL/cc Foley probe were used (►**Figure 1**). The syringe was sectioned according to the planned depth based on preoperative imaging. Initially, with the bipolar forceps, we made a small corridor through the white matter until reaching the lesion (►**Figure 2A**). After that, the Foley probe balloon is progressively inserted and smoothly inflated along the path to promote the necessary space to position the tubular retractor (►**Figure 2B**). The cut end of the syringe was trimmed with a drill to make it blunt. Once the path was ready, the probe was inflated with saline solution inside the syringe, obliterating it completely (►**Figure 2C**). This strategy is useful to prevent herniation of the brain parenchyma into the syringe. Once the retractor was positioned in the desired location, the probe was deflated, enabling access to the lesion (►**Figure 2D**). In this case, the syringe was the retractor itself, while the Foley probe served as a white matter route dissector.

The retractor was not externally fixed. This dynamic approach enabled us to angle the retractor in different directions for the procedure, considering the high volume of the lesions. After proper resection of the lesion, hemostasis was performed and the tube was carefully removed along the path in a straight line, with the performance of hemostasis, if necessary, along the white matter route. All resected material was sent for anatomopathological and immunohistochemical studies.

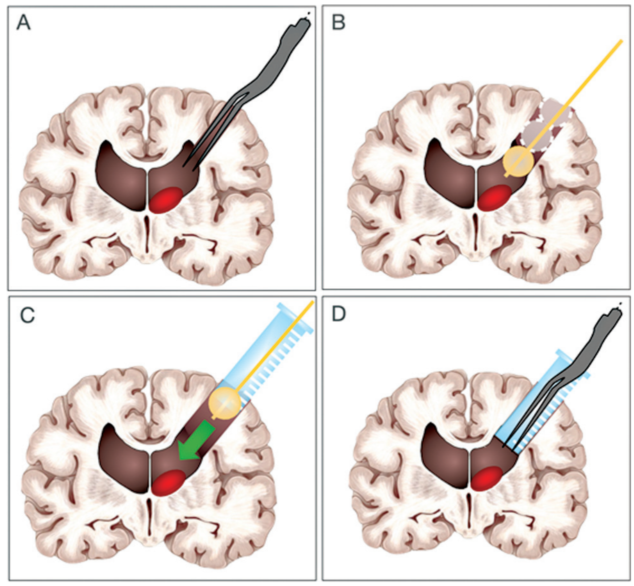

Fig. 2 The bipolar forceps being used to make a small corridor through the white matter until reaching the lesion (**A**). The Foley probe being progressively inserted and inflated along the path to promote the necessary space to position the tubular retractor (**B**). Insertion of the syringe over the tube to prevent herniation of the brain parenchyma into the syringe (**C**). Tubular retractor positioned to facilitate surgical handling of the intraventricular lesion (**D**).

Results

Case 1

Case 1 was that of a 36-year-old female patient with a 2-year history of holocranial and moderate progressive headache with normal neurological examination. Brain CT and MRI scans were performed (►**Figure 3**), which showed an intraventricular lesion (right ventricular atrium) with significant contrast enhancement. The surgical procedure was uneventful, using a tubular transparietal route with a piecemeal resection strategy (►**Figure 4**). The patient evolved in the follow-up without motor and sensory deficits. The pathological examination showed a grade-I meningioma according to the 2021 World Health Organization (WHO) grading system, and an immunohistochemical study revealed focal expression of epithelial membrane antigen (EMA) and positivity for progesterone receptor, confirming the meningothelial histogenesis of the lesion. The cell proliferation index (Ki-67) was estimated to be of 1%.

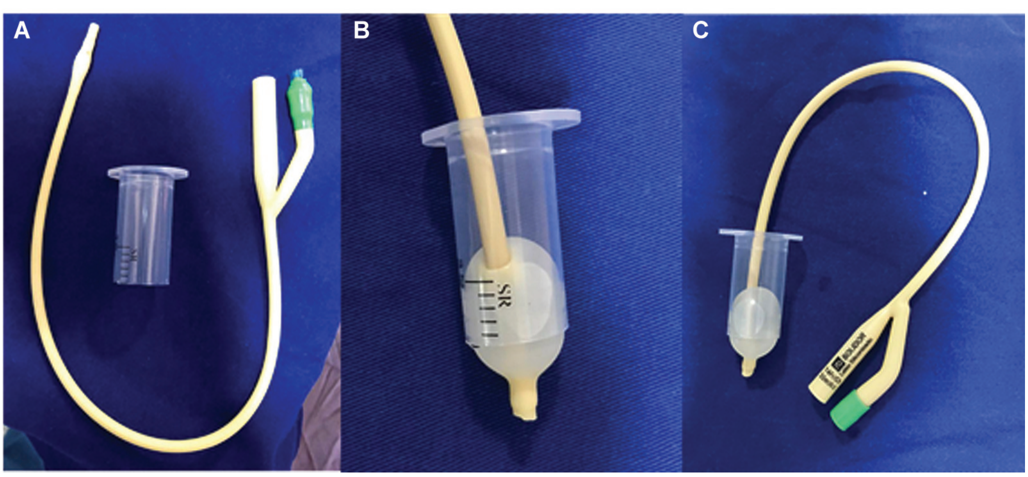

Fig. 1 The syringe used as the tubular retractor was sectioned based on the depth of the lesion acquired through neuronavigation and/or MRI scans (**A**). After the Foley probe balloon had been progressively inserted and smoothly inflated along the path to promote the necessary space to position the tubular retractor, the probe must be inflated with saline solution inside the syringe, obliterating it completely (**B**,**C**).

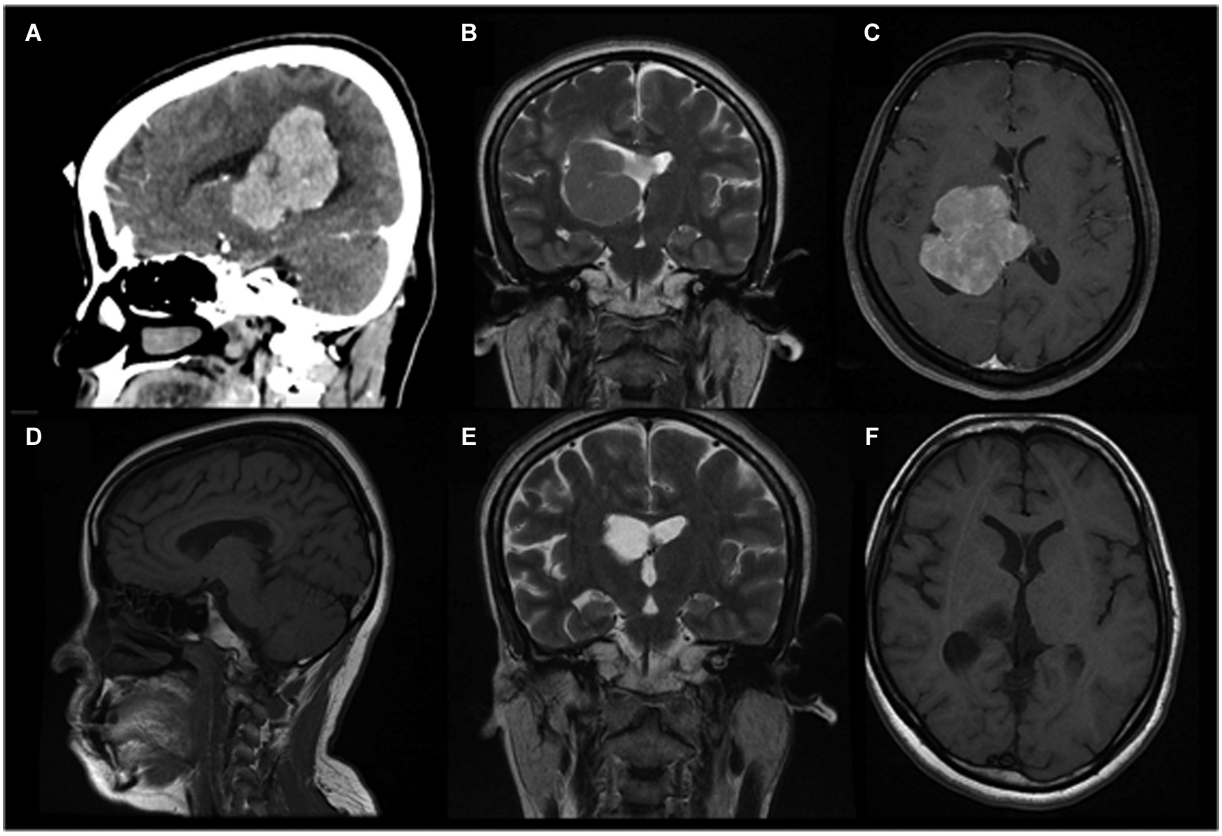

Fig. 3 Preoperative sagittal enhanced brain CT (**A**) scan. Preoperative MRI scans with coronal T2-weighted (**B**) and axial gadolinium-enhanced T1-weighted (**C**) images showing an expansive lesion in the right atrial region of the lateral ventricle. (**D-F**) Postoperative MRI scans.

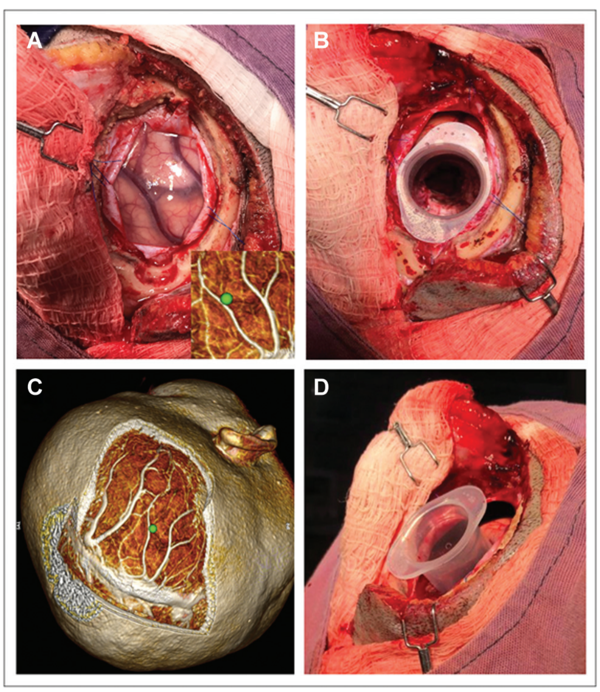

Fig. 4 Visualization of the cortical surface after craniotomy and opening of the dura mater and its relationship with the image of the 3D reconstruction. The green spot shows the surgical entry point in the brain parenchyma (**A**) after insertion of the tubular retractor with Foley probe dilatation and removal (**B**). Presurgical 3D reconstruction of the transparietal entry point (**C**). Syringe positioned to serve as a tubular retractor for tumor resection (**D**)

Case 2

Case 2 was that of a 17-year-old female patient with a previous history of headache, nausea, and syncope. The neurological examination revealed bilateral papilledema on funduscopy, and the motor and sensory functions were preserved. A Gadolinium-enhanced MRI scan with T1-weighted images (►**Figure 5**) showed an isointense expansive right ventricular/periventricular paramedian solidocystic lesion with central heterogenous contrast enhancement measuring approximately $4.0 \times 2.6 \times 3.8$ cm, in addition to a lesion with a right periventricular/frontal cystic component, with peripheral vasogenic edema, measuring $5.0 \times 4.0 \times 3.5$ cm. Resection was uneventful with the use of a tubular retractor, We initially approached the cystic component, followed by the solid component of the tumor. The immunohistochemical study revealed diffuse expression of glial fibrillary acidic protein (GFAP)/S100 protein and low cell proliferation index (Ki-67 < 1%). The pathological findings were indicative of pilocytic astrocytoma (grade-I according to the 2021 WHO grading system). In the follow-up, the patient presented good recovery without any motor or sensory deficits or other complications, with regression of the papilledema.

Case 3

Case 3 is that if a 28-year-old male patient with a history of left paresthesia, severe headache, visual blurring, and loss of strength in the left side of the body, which was worse in the lower limb. A neurological examination showed preserved

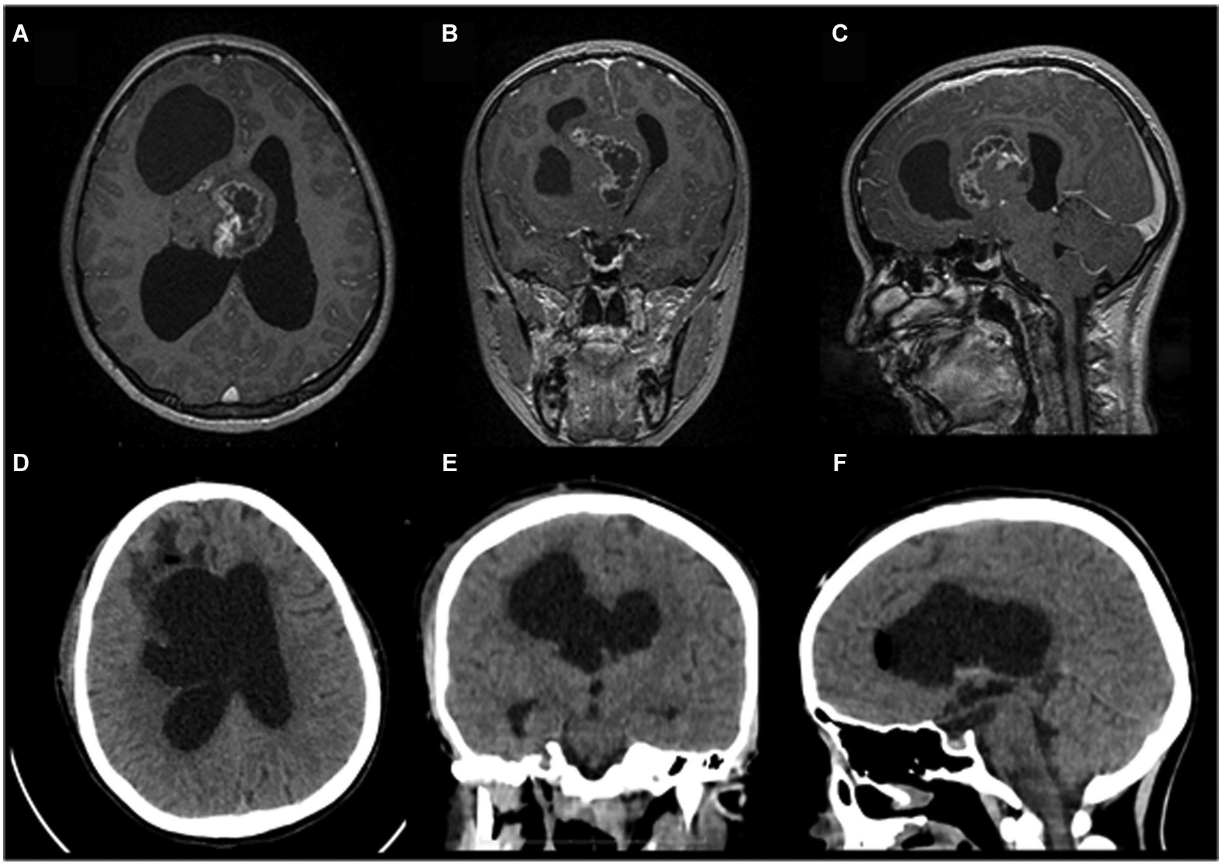

Fig. 5 (A-C) Gadolinium-enhanced T1-weighted MRI scans in the axial, coronal, and sagittal sections showing preoperative pilocytic astrocytoma measuring $9.0 \times 6.4 \times 7.4$, extensively compromising the corpus callosum. (D-F) Postoperative brain CT showing gross total resection.

cranial nerve functions, left grade-3 complete hemiparesis and left hemihypoesthesis with asymmetric deep tendon reflexes, with grade +2/4 on the right side of the body and grade +3/4 on the left side of the body. Coordination tests were preserved. A Brain MRI (►**Figure 6**) showed a deep and large right frontoparietal lesion, infiltrating the right cingulate gyrus and corpus callosum, intralesional high signal in the T1-weighted image suggestive of a hemorrhagic component and small areas of contrast enhancement. Its local expansive effect determined compression of the lateral ventricles and third ventricle. The tubular surgery was performed as previously described, achieving gross total resection (►**Figure 7**). The patient evolved without any complications or additional motor or sensory deficits, maintaining hemiparesis in the left side. The pathological examination showed a hypercellular neoplasm of anaplastic morphology, with a fibrillar background, frequent mitotic figures, including atypical forms. Vascular proliferation and foci of necrosis were also observed. The immunohistochemical study revealed GFAP and S100 protein expression, confirming the glial histogenesis of the neoplasia. We also observed expression of the p53 protein in a mutated pattern, positivity for isocitrate dehydrogenase 1 (IDH1) R132H mutation and a Ki-67 cell proliferation index of 20%. The pathological findings were compatible with an IDH-mutated grade-IV astrocytoma (according to the 2021 WHO grading system).

Case 4

Case 4 was that of a 51-year-old female patient with history of frontal headache with associated vertigo who was refractory to medication use. A neurological examination showed diplopia, right abducens nerve paresis, and grade-4 left hemiparesis. A brain MRI showed expansive intraventricular lesions. Surgery was performed uneventfully with the help of a tubular retractor, and the patient evolved maintaining hemiparesis in the left side, with no cranial nerve deficit. A pathological examination showed a low-grade fusocellular neoplasm, with immunohistochemical findings of a grade-II CD34 positive hemangiopericytoma/solitary fibrous tumor, with a Ki-67 cell proliferation index $< 1\%$. The preoperative images and step-by-step surgery of this case are illustrated in a video with a narration of the tubular retraction technique.

All microsurgical instruments, in addition to the ultrasonic aspirator, were used through the tube without ergonomic issues or viewing limitations. Radical resection was achieved in all cases, and the samples collected were satisfactory regarding the results of the anatomopathological study. All patients evolved without any additional deficits and with adequate postoperative image control.

The lack of an external fixation system did not limit the procedure. Positioning of the standalone tubular retractor was feasible, and the workability of the syringe facilitated the surgical procedure, and it could be repositioned whenever necessary, enabling freedom of angulation of approximately

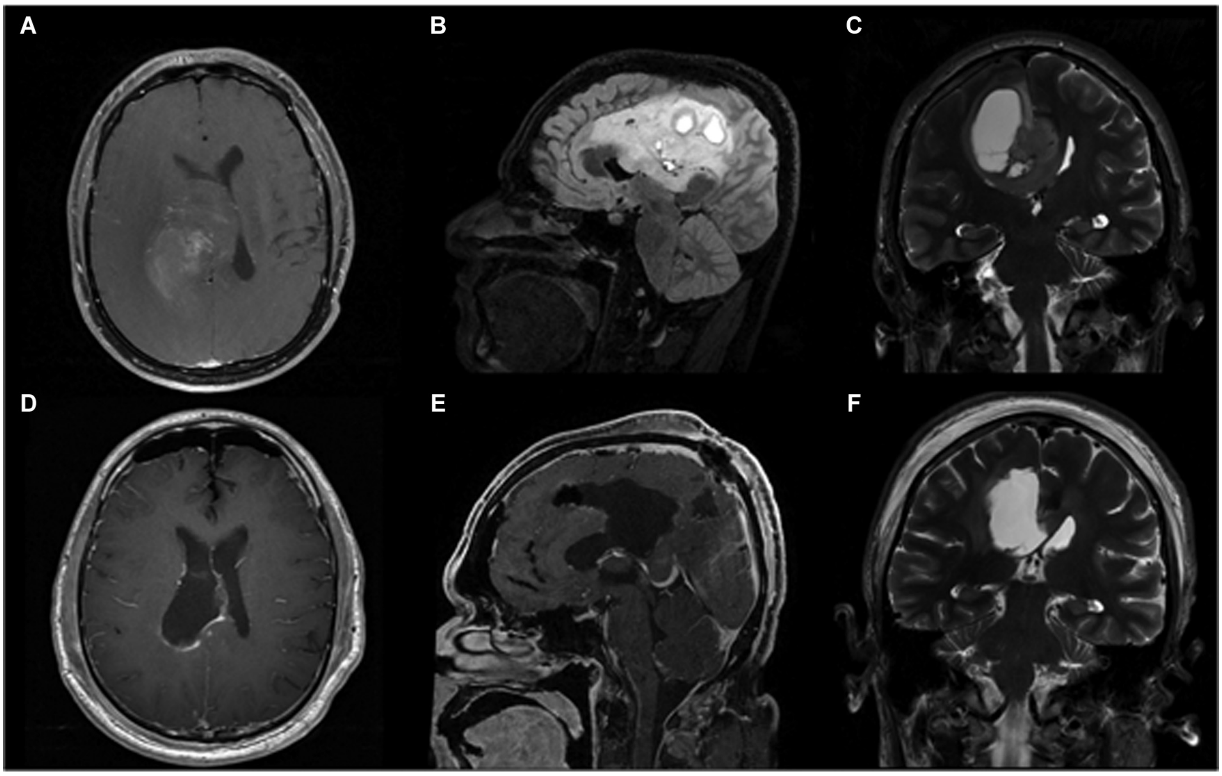

Fig. 6 Axial gadolinium-enhanced T1-weighted (**A**), sagittal FLAIR (**B**) and coronal T2 weighted MRI (**C**) showing a right deep frontoparietal lesion with infiltration of the right cingulate gyrus and corpus callosum. Postoperative images: axial gadolinium-enhanced T1-weighted (**D**), sagittal gadolinium-enhanced T1-weighted (**E**) and coronal T2 weighted MRI (**F**) showing postoperative result with gross total resection without complications.

30° in all directions. Neuronavigation can be useful to define the path to the injury. Due to the dilation provided by the Foley probe, which worked as a dissector the white matter fibers prior to placement of the syringe retractor, the pressure exerted through the syringe was minimized during its introduction into the brain parenchyma. The entire

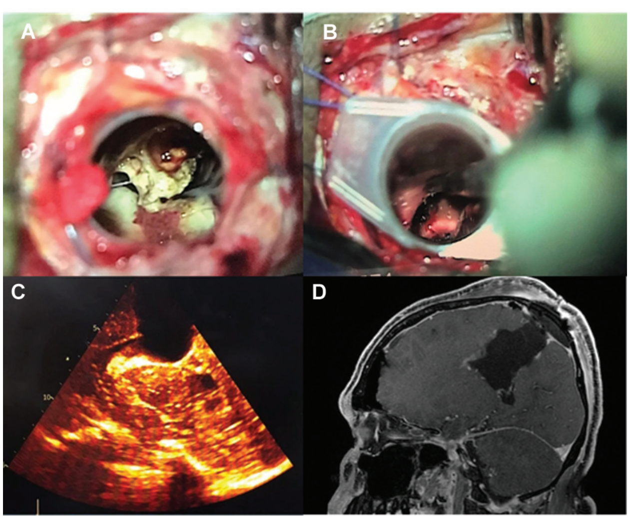

Fig. 7 Lesion visualized through the microscope tubular view (**A**); intraoperative mobilization of the syringe retractor enabling different angles of work (**B**); postoperative ultrasound image showing hypoechoic area and the path to the tumor (**C**); and corresponding sagittal gadolinium-enhanced T1-weighted MRI (**D**).

retracted parenchyma could be visualized through the transparent surface of the syringe. When it was removed, the parenchyma returned to its original shape, with no apparent damage.

The technique herein reported was in line with other methods of tubular retraction described in the literature due to the pressure exerted radially on the parenchyma, making this retraction mechanism unlikely to cause damage to the brain tissue, as described in ►**Table 1**.

Discussion

The use of the tubular retractor described in the present study proved to be a low-cost, simple, and effective technique to visualize deep lesions, especially when located in or related to the lateral ventricle. The approaches were less invasive compared with the classic microsurgical alternative with fixed retractors. Furthermore, the transparent surface of the retractor made it possible to view the retracted parenchyma, in addition to protecting it throughout the procedure. This approach enabled the resection of difficult-to-access lesions with different histology (glioblastoma, meningioma, and pilocytic astrocytoma).

In the mid-nineteenth century, there was a significant change in the field of neurosurgery, involving advances in concepts such as antisepsis, asepsis, anesthesia, brain localization, and intracranial pressure control. These were of paramount importance to reduce morbidity and mortality

Table 1 Literature review of syringe port as a tubular retractor technique for neurosurgical procedures

Author	Number of patients	Diameter of syringe	Insertion technique and path dilatation	Navigation system	Phathology	Complications
Vaish et al. 2014[26]	20	13 mm (5mL)	Syringe introduced with a Teflon trocar	Under navigation guidance (Brainlab system)	Colloid cysts	No complications or postoperative morbidity related
Almubarak et al. 2018[22]	9	17 mm (10 mL)	Syringe introduced through transsulcal or transgyral approach, without pior dilation	Under navigation guidance	Glioblastoma, gliosarcoma, toxoplasmosis	Transient afasia ($n = 2$), weakness ($n = 3$), 6th cranial nerve palsy ($n = 1$), memory impairment ($n = 1$)
Singh et al. 2018[23]	62	2.06 mm (5mL); 14.5 mm (10mL); and 19.3mm (20 mL)	Syringe introduced with plastic trocar	Under navigation guidance	Gliomas, cavernomas, metastasis, lymphomas, intracranial bleeding	No complications or postoperative morbidity related
Sharif et al. 2019[24]	Not reported	14 mm (5 mL); 17 mm (10 mL); and 20 mm (20 mL)	Syringe introduced with plastic trocar	Under navigation guidance	Malignant tumors and intracerebral hematomas	No complications or postoperative morbidity related
Zhenzhu et al. 2020[25]	7	5-mL and 10-mL syringes	Glove-syringe introduced with trocar	Under navigation guidance	Intracerebral hematomas	No complications or postoperative morbidity related
Moraes et al. (present study)	4	20mm (20 mL)	Prior dilation with Foley probe	Under navigation guidance (Horos software, version 1.1.7)	Meningioma, astrocytoma, metastasis	No complications or postoperative morbidity observed

in patients who underwent neurosurgery, which encouraged professionals in the area to turn their attention to more effective procedures and methods. With intracranial surgery becoming more accessible, there was a progressive increase in the need for techniques for brain retraction to better visualize the surgical field.[6]

At the beginning of the twentieth century, the first fixed retractors were created, which did not require fixed handling by an assistant. The first fixed retractor, called the Weitlaner retractor, was created in 1905 by Franz Weitlaner.[6] The use of tubular retractors became popular in the late twentieth century, and it was first described by Kelly et al.,[7] from the Mayo Foudation's Department of Neurosurgery, in Rochester, Minnesota, United States, in the late 1980s, as a useful alternative in minimally-invasive surgery, especially in cases of patients with deep tumors in the brain parenchyma. The use of this technique in neurosurgeries for lesions in anatomical areas such as the ventricles, the basal nuclei, the posterior thalamus, the insular cortex, and the basal cisterns is well described in the literature,[8] with a reduction in morbidity associated with the approach to these lesions.[2,9]

The first commercial model of tubular retractor to be used was the METRx (Medtronic) system, created in 1985, which consists of alternating conjugated tubes of variable lengths and widths, which is more used in spinal surgeries.[1] Before that, devices such as syringes or tube speculums made of polyethylene were used as a form of tubular retractor.[1] Another well-known commercial model available is the ViewSite (Vycor Medical), which is a clear plastic retractor that also offers the possibility to change the length in 3 different sizes (3 cm, 5 cm and 7 cm) and 4 widths (12 cm, 17 cm, 21 cm, and 28 mm).[10] There is no statistical difference reported in the literature between the different commercial types of tubular retractors regarding the rate of postoperative complications.[11,12]

Studies show an equivalence in effectiveness when different types of retractors were compared. A meta-analysis performed by Marenco-Hillembrand et al.[11] on four different types of tubular retractors, including models such as the ViewSite and METRx, showed a complication rate of 9% in 309 surgeries performed, with no higher percentage linked to one type over another.

There is a report[13] on the use of tubular retractors in the surgical management of different types of pathologies in the brain parenchyma, such as intracranial hemorrhages, gliomas, vascular lesions such as cavernomas and arteriovenous malformations, meningiomas, and brain metastases, among others.

Despite being an extremely useful method to access deep lesions, the improper and careless use of this technique can result in cerebral edema and ischemia, generating new iatrogenic lesions.[14] In order to avoid such complications, it is necessary to correctly plan the surgical path, the diameter of the retractor, and the pressure exerted by it on the brain structures. In relation to damage to the brain parenchyma, an animal study[15] has shown that pressures of 25 mmHg exerted focally in a region of the brain parenchyma can cause electroencephalographic alterations. Furthermore, Rosenørn[16] reports that focal pressures > 30 mmHg can cause a decrease in local blood flow in the cerebral parenchyma, especially if this pressure is maintained for more than 2 hours.[17] Ogura et al.[14] showed that the pressure exerted by a tubular retractor did not exceed 10 mmHg, which did not result in ischemic complications in the brain tissue.

A study[18] using MRI, which evaluated the damage caused by tubular retractors in the postoperative period of intraparenchymal lesions through T2 fluid-attenuated inversion recovery (FLAIR) and diffusion-weighted imaging DWI sequences, did not show a statistically significant increase in hypersignal images in the FLAIR sequence, suggesting a lower risk of vasogenic edema due to brain damage in the postoperative period. This reinforces the concept that the use of tubular retractors are potentially less traumatic than other brain retraction techniques, although there is not enough data in the literature for comparison purposes.[18] However, this same study[18] also demonstrated, through DWI, evidence of edema of cytotoxic origin in the tissue around the retracted area. Despite this finding, much of the brain damage caused by tubular retractors is transitory and self-limited.[19]

The lower probability of traumatic events in tubular retraction may be due to the reduced pressure exerted by tubular retractors, which is circumferentially distributed across the cylindrical surface of the tube, unlike other types of retractors such as blades, which exert a nonuniform pressure on the brain.[7,20] Furthermore, with tubular retractors, white matter tracts can be divulged and, consequently, preserved, rather than sectioned, through the passage of the blunt tip of the retraction instrument and progressive dilation technique.[21] It has been described[15,16] that tubular retractors can be harmful to the parenchyma if they exceed pressures between 25 and 30 mmHg. Due to the technical refinement described in the present case series, with path dilation performed by the Foley probe and the diameter of the syringe used (20 mm), which is compatible with other tubular retraction instruments described in the literature and commercially available, these pressures were most likely not exceeded in the cases herein reported.

Compared to other studies, the use of tubular structures as brain retractors resulted in fewer intraoperative and postoperative complications, such as lower levels of blood loss and shorter hospital stay, when compared with conventional techniques.[2] In addition, it presents other advantages such as smaller corticectomy (of only 2 cm), no thin edges like mobile retractors, and less brain damage due to the malleability of the tube, not to mention the fact that it is simple to position, safer, easy to use, and low-cost.[3]

It is also worth highlighting the versatility of tubular techniques. There is the possibility of angulation of the tube in different directions, with a range of approximately 30°, as well as the possibility of associating auxiliary techniques such as endoscopy, further facilitating the visualization of the lesion in any perspective desired by the neurosurgeon. Furthermore, the 20-mm diameter of the syringe enabled the use of 2 microsurgical instruments at the same time, such as bipolar forceps and ultrasonic aspirator. The syringe was also an easy-to-handle method, as it did not need a permanent fixation such as other retractors. The flanges of the syringe served as its own retainer and were supported on the cortical surface without any additional damage. The lack of an external fixation system did not limit the procedure. This method can also be conveniently associated with neuronavigation and intraoperative ultrasound. Ultrasonography was particularly useful in assessing the degree of lesion resection in real time. It is one of the main strategies, besides neuronavigation, to optimize the use of tubular retractors in the intraoperative period and increase the extent of resection.[9]

There are reports in the literature of tubular retraction methods with syringes associated with microsurgical techniques such as endoscopy or microscopy, which are used in the resection of lesions such as intracerebral hematomas, glioblastomas, and gliosarcomas, among others (►**Table 1**). Almubarak et al.[22] described a technique similar to ours, in which a retraction system with a syringe and a Foley probe was used, which has been shown to be useful in preventing trauma to the brain parenchyma in the path to the injury. Other articles[23–25] have also shown syringe techniques associated with trocar designed from medical-grade plastic dilators or gloves as an alternative. None of them showed significant rates of intraoperative or postoperative complications.[22–26] We believe that our technique shares the same advantages even with important differences, such as previous dilatation with the Foley probe, which provides security in preventing brain damage and probably less damage to the white matter fibers. Futhermore, our technique did not need an external fixator to secure the retractor, since the flanges of the syringe served as its own retainer. In addition, the tube itself did not cause damage due to the trim of the cut surface prior to surgery, the radial pressure exerted by the tube on the parenchyma resulted in reduced risk of ischemia, and because its 20-mm diameter is similar to that of other forms of tubular retraction with low complication rates described in the literature and commercially available, such as the ViewSite.[11] Additionally, the probe did not cause thermal injury to the brain parenchyma due to the material the syringe was made of, which presented low heat absorption.

Neuroradiological planning in this approach is of paramount importance. The neurosurgical team must have acquired brain MRI and/or CT scans following a volumetric protocol. Therefore, oblique reconstructions in the coronal and sagittal planes, perpendicular to the approach, are possible. Thus, the exact location for corticectomy and insertion of the tubular retractor can be planned, as well as the size that the syringe must have for its correct intra-operative positioning and to estimate the tube angulation.

Despite being commercially available, tubular retractors are not easily present in public services and are hardly available through health insurances. It is a problem present in low-to-middle-income countries, such as Brazil. As a result, there is a demand to develop creative alternatives to fulfill this need. Due to this necessity, this method can be a way to bypass those difficulties.

Conclusion

The use of the syringe as a tubular retractor associated with the Foley probe as a surgical port dilator was useful in enabling gross total resection of intracranial tumors related to the lateral ventricle, not limiting the use of auxiliary instruments, neither of microsurgical instruments; therefore, it is an affordable, safe, and inexpensive method. More studies with a higher number of patients are needed to evaluate the possible damage caused by tubular retractors, especially in comparison with older retraction methods, to better guide the technique and use of tubular retractors.

Competing Interests and Funding
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 nonfinancial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in the present manuscript. No funding was received for the present research.

Conflict of Interests
The authors have no conflict of interests to declare.

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References

1 Kim YB, Hyun SJ. Clinical applications of the tubular retractor on spinal disorders. J Korean Neurosurg Soc 2007;42(04):245–250. Doi: 10.3340/jkns.2007.42.4.245
2 Assina R, Rubino S, Sarris CE, Gandhi CD, Prestigiacomo CJ. The history of brain retractors throughout the development of neurological surgery. Neurosurg Focus 2014;36(04):E8. Doi: 10.3171/2014.2.FOCUS13564
3 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(01):74–77. Doi: 10.4103/0028-3886.76870
4 Fernandes de Oliveira Santos B, de Araujo Paz D, Fernandes VM, et al. Minimally invasive supratentorial neurosurgical approaches guided by Smartphone app and compass. Sci Rep 2021;11(01):6778. Doi: 10.1038/s41598-021-85472-3
5 Santos BFO, Costa MDS, Centeno RS, et al. Clinical Application of an Open-Source 3D Volume Rendering Software to Neurosurgical Approaches. World Neurosurg 2018;10:864–872. Doi: 10.1016/j.wneu.2017.11.123
6 Lener S, Wipplinger C, Hernandez RN, et al. Defining the MIS-TLIF: A Systematic Review of Techniques and Technologies Used by Surgeons Worldwide. Global Spine J 2020;10(2, Suppl)151S–167S. Doi: 10.1177/2192568219882346
7 Kelly PJ, Goerss SJ, Kall BA. The stereotaxic retractor in computer-assisted stereotaxic microsurgery. Technical note. J Neurosurg 1988;69(02):301–306. Doi: 10.3171/jns.1988.69.2.0301
8 Bosnjak R, Antolin A, Jeglic A, Felbabic T, Velnar T. Navigated Endoport in the Purely Endoscopic Microsurgery of Intraventricular and Other Deep-Seated Brain Lesions: A Case Report. Acta Med Acad 2020;49(Suppl 1):70–77. Doi: 10.5644/ama2006-124.309
9 Zammar SG, Cappelli J, Zacharia BE. Utility of tubular retractors augmented with intraoperative ultrasound in the resection of deep-seated brain lesions. Cureus 2019;11(03):e4272. Doi: 10.7759/cureus.4272
10 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. Doi: 10.4103/sni.sni_62_18
11 Marenco-Hillembrand L, Prevatt C, Suarez-Meade P, Ruiz-Garcia H, Quinones-Hinojosa A, Chaichana KL. Minimally invasive surgical outcomes for deep-seated brain lesions treated with different tubular retraction systems: a systematic review and meta-analysis. World Neurosurg 2020;143:537–545.e3. Doi: 10.1016/j.wneu.2020.07.115
12 Echeverry N, Mansour S, MacKinnon G, Jaraki J, Shapiro S, Snelling B. Intracranial Tubular Retractor Systems: A Comparison and Review of the Literature of the BrainPath, Vycor, and METRx Tubular Retractors in the Management of Deep Brain Lesions. World Neurosurg 2020;143:134–146. Doi: 10.1016/j.wneu.2020.07.131
13 Marenco-Hillembrand L, Alvarado-Estrada K, Chaichana KL. Contemporary surgical management of deep-seated metastatic brain tumors using minimally invasive approaches. Front Oncol 2018;8:558. Doi: 10.3389/fonc.2018.00558
14 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. Doi: 10.1007/s00701-006-0768-7
15 Greenberg IM. Self-retaining retractor and handrest system for neurosurgery. Neurosurgery 1981;8(02):205–208. Doi: 10.1227/00006123-198102000-00009
16 Rosenørn J. The risk of ischaemic brain damage during the use of self-retaining brain retractors. Acta Neurol Scand Suppl 1989;120:1–30. Doi: 10.1111/j.1600-0404.1989.tb08017.x
17 Zagzoog N, Reddy KK. Modern Brain Retractors and Surgical Brain Injury: A Review. World Neurosurg 2020;142:93–103. Doi: 10.1016/j.wneu.2020.06.153
18 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. Doi: 10.3171/2015.4.JNS142576
19 Eliyas JK, Glynn R, Kulwin CG, et al. Minimally Invasive Transsulcal Resection of Intraventricular and Periventricular Lesions Through a Tubular Retractor System: Multicentric Experience and Results.

World Neurosurg 2016;90:556–564. Doi: 10.1016/j.wneu.2015.12.100

20 Eichberg DG, Buttrick S, Brusko GD, Ivan M, Starke RM, Komotar RJ. Use of tubular retractor for resection of deep-seated cerebral tumors and colloid cysts: single surgeon experience and review of the literature. World Neurosurg 2018;112:e50–e60. Doi: 10.1016/j.wneu.2017.12.023

21 Greenfield JP, Cobb WS, Tsouris AJ, Schwartz TH. Stereotactic minimally invasive tubular retractor system for deep brain lesions. Neurosurgery 2008;63(4, Suppl 2)334–339, discussion 339–340. Doi: 10.1227/01.neu.0000334741.61745.72

22 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. Doi: 10.1016/j.wneu.2018.05.236

23 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. Doi: 10.1016/j.wneu.2018.03.019

24 Sharif S, Shaikh MY, Ali SM. Novel Tool for Minimally Invasive Brain Surgery-Syringe Port System. World Neurosurg 2019;131:339–345. Doi: 10.1016/j.wneu.2019.06.202

25 Zhenzhu L, Ruiyu X, Wei C, et al. Novel Cost-Effective Tubular Port Based on Glove and Syringe for Endoscopic Surgery of Intracerebral Hematomas. World Neurosurg 2020;135:367–374.e1. Doi: 10.1016/j.wneu.2019.11.097

26 Vaish M, Patir R, Prasad R, Agrawal A. Single port microsurgical technique for excision of third ventricular colloid cysts. Asian J Neurosurg 2014;9(04):189–192. Doi: 10.4103/1793-5482.146599

