OBJECTIVE: Minimally invasive transportal resection of deep intracranial lesions has become a widely accepted surgical technique. Many disposable, mountable port systems are available in the market for this purpose, like the ViewSite Brain Access System. The objective of this study was to find a cost-effective substitute for these systems.

METHODS: Deep-seated brain lesions were treated with a port system made from disposable syringes. The syringe port could be inserted through minicraniotomies placed and planned with navigation. All deep-seated lesions like ventricular tumours, colloid cysts, deep-seated gliomas, and basal ganglia hemorrhages were treated with this syringe port system and evaluated for safety, operative site hematomas, and blood loss.

RESULTS: 62 patients were operated on during the study period from January 2015 to July 2017, using this innovative syringe port system for deep-seated lesions of the brain. No operative site hematoma or contusions were seen along the port entry site and tract.

CONCLUSIONS: Syringe port is a cost-effective and safe alternative to the costly disposable brain port systems, especially for neurosurgical setups in developing countries for minimally invasive transportal resection of deep brain lesions.

INTRODUCTION

Deepleft-seated brain lesions have been a technically challenging surgical entity. Surgery for deep intraparenchymal and intraventricular lesions is associated with higher risks of complications like surgical bed hematomas and retraction-induced contusions. A great deal of attention has focused lately on improving the efficacy and safety of removing such lesions.

The keyhole concept of minimally invasive brain surgeries has been gaining widespread acceptance. Advancements in neuroimaging, operative microscopes, cranial endoscopes, and navigation have made it possible to make tailored smaller craniotomies to achieve satisfactory surgical exposure.

Circular retractors or dilators have become a cornerstone in keyhole brain surgeries. The tubular retractors introduced the concept of creating a surgical corridor using progressive dilators to safely dilate the brain tract during the approach to a deep-seated lesion. The use of such dilators leads to splitting of the neural tissue en route to the lesion and avoids direct damage to the parenchyma, in a fashion similar to the keel of a ship. A wide number of such retractors are now commercially available for use in neurosurgery.

We present our experience with an indigenously designed brain port system using common syringes to provide a cost-effective alternative to the commercially available brain ports.

METHODS AND MATERIALS

Perioperative Evaluation

The diagnostic work up for patients planned for transportal surgery includes 3-dimensional contrast-enhanced magnetic
resonance imaging. In emergency conditions, like intraparenchymal hemorrhages, thin-slice computed tomography is appropriate. Planning a tailored craniotomy for lesions in close proximity to the eloquent brain areas requires functional mapping and tractography.

The procedure is performed with the patient under general anesthesia and guided by neuronavigation. The patient is positioned in a Mayfield 3-pin head holder. The head is positioned in such a way that the planned cortical site is the highest and the surgical tract will be nearly vertical to the floor.

**Craniotomy, Corticectomy, and Trajectory**

Craniotomy, corticectomy, and trajectory are guided by neuronavigation. These are planned based on known safe areas of entry and on knowledge of tract disposition on magnetic resonance tractography.

The craniotomy is roughly 3 cm in diameter. This allows adequate margins for angulation of the port intraoperatively. The craniotomy is made with a high-speed craniotome. The dura mater is hitched and opened in a cruciate fashion. The arachnoid and pia mater are coagulated and cut.

**Port Design and Preparation**

The syringe port can be tailored as needed before the dural incision. The length of the syringe port can be judged by the depth of the tumor from the skin level. The port needs to be long enough to reach the deepest portion of the tumor along the planned trajectory. A long port can be slightly withdrawn if required, but a shorter port will need to be replaced in case of intraoperative problems. A shorter port will also hamper angulation of the port while accessing the margins of tumor after initial decompression.

The size of the port is determined by the nature of the lesion to be dealt with and its expected vascularity. The plastic 5-mL syringe (BD, Becton Dickinson, Gurugram, Haryana, India) has an outer diameter (OD) of 2.06 mm, the 10-mL syringe has an OD of 14.5 mm, and the 20-mL syringe has an OD of 19.13 mm. A 5-mL syringe port is used for relatively avascular lesions like colloid cysts and hematomas, and a 20-mL syringe is used for highly vascular tumors like central neurocytomas. For intermediate lesions, a syringe port made from a 10-mL syringe provides adequate visualization.

The hub and front end of the barrel of a syringe are cut. The length of the port is measured from the barrel flange of the syringe to the cut end of the barrel. The cut end of barrel is smoothed.
A medical-grade plastic dilators (Figure 1A) is used as a trocar for the syringe port. The front end of this trocar can be made conical to facilitate separation of white matter fibers. The customized syringe ports (Figure 1B) are now passed over the plastic dilators (Figure 1C). Tool adaptors can be attached to the rear end of the plastic trocar for neuronavigation (Brainlab AG, Feldkirchen, Germany) (Figure 1D).

Port Introduction

The syringe port with trocar is introduced under navigation guidance gradually to allow the brain tissue to adapt, in a gentle twisting motion (Video 1). Once inserted up to the desired depth, the trocar is removed while keeping the syringe port in situ. The syringe flanges act as points of counterforce during removal of the trocar from the syringe port. The syringe port can be pushed out by a swollen brain. This can be prevented by applying gentle pressure on the syringe flange, with a flat retractor attached to a Leyla arm.

The microscope is brought in at this point, and lesion removal can be undertaken in a standard fashion.

Port Removal and Closure

After satisfactory hemostasis, the port is removed slowly, visualizing the underlying cortex for bleeding points as the tube is pulled out. The cortex can be covered with Surgicel (Ethicon, Johnson & Johnson, Hato, San Lorenzo, USA) for effective hemostasis.

The dura mater closure invariably needs a graft, which can easily be obtained from the pericranium. The bone flap is refixed with titanium miniplates.

RESULTS

From January 2015 to July 2017, we operated on 62 patients using a syringe port retractor system. The patients’ ages ranged from 6 to 79 years. Forty-five (72.5%) patients were male and 17 were female. Neuronavigation was used in 61 patients (98.3%), and 1 patient with a large intracranial bleed was operated on without navigation. Thirty-six (58%) patients had deep parenchymal lesions, which included gliomas, metastasis, cavernomas, lymphomas, and intracranial bleeds. Twenty-four (38.7%) patients had surgery for intraventricular lesions using this technique, which included 14 cases of colloid cysts, 5 cases of central neurocytomas, and 5 cases of other intraventricular lesions. Two (3.2%) patients had their infratentorial tumors (one hemangioblastoma and one pilocytic astrocytoma) excised by this port technique. Twenty-two (35.4%) patients were operated on with use of a 5-mL syringe port, 35 (56.4%) patients were operated on with a 10-mL syringe port, and 5 (8.0%) patients were operated on with a 20-mL syringe port. All 5 patients operated on with 20-mL syringe port had central neurocytomas.

No significant intraoperative complications (requiring change to a standard flat retractor) were encountered in any patient. No patient required re-exploration for an operative site hematoma. One patient with recurrent third ventricular pilocytic astrocytoma died of postoperative hypothalamic dysfunction. Three (4.8%) patients had some kind of additional neurologic deficits after the surgery.

DISCUSSION

Deep-seated brain lesions pose unique surgical challenges even to the most experienced surgeon. The traditional ways of resecting such deep lesions have involved the use of flat retractors to keep the surgical corridor open after a corticectomy. The unidirectional retraction can cause significant retraction injury to the underlying cortex. Besides damage from direct retractors, the cortex can also be damaged from the repeated movement of instruments through the surgical corridor and rubbing of the instrument shafts against the cortex.

Circular or tubular retractors dissipate the amount of retraction force in a circumferential manner to reduce the amount of force per unit of cortex under retraction, thereby reducing the damage to the brain parenchyma along the tract. Such circular retractors provide a secure corridor preventing injury from the shaft of instruments, prevent brain bulge into the operative field, provide good light penetration, and allow the use of standard neurosurgical instruments in a 2-handed manner. These retractors have provided a new dimension to keyhole neurosurgery.

Several forms of tubular retractors have been described in the literature. Some have become commercially available as well, like the Viewsite Brain Access System, Vycor Medical Inc., Boca Raton, Florida, USA and NICO BrainPath (NICO corporation, Indianapolis, Indiana, USA). Many reports have been published elaborating the use, benefits, and integration of such devices with other equipment like navigation, microscopes, or endoscopes.3-7 There are also some innovative designs of tubular brain ports, which have been used with good results.8

Different tubular retractor systems have different advantages and disadvantages. Perhaps the 2 most important requirements for the use of such retractors is their cost and availability. Commercially made, specifically designed retractors are not widely available, and their cost is a hindrance to widespread acceptance. The use of syringe ports described in this report circumvents these 2 problems. Syringes are among the cheapest medical equipment and are universally available. A tubular port made from a syringe is lightweight and translucent, does not require a fixed holding arm, and is easily maneuverable in all directions. When a syringe port is introduced in a brain with elevated intracranial pressure (ICP), it may be pushed out by the elevated ICP, and the syringe port needs to be supported during the initial phase of tumor decompression. Putting a flat retractor onto a Leyla arm (Video 1) to support the syringe flange prevents it from coming out. On the other hand, after tumor decompression, heavy tubular retractors tend to sink in because of their weight if not held with a rigid holding arm. This does not happen with a syringe port because it is very lightweight and the syringe flanges prevent sinking in.

The syringe port has already been described in the literature.9 Our technique differs from the technique mentioned in that report. We do not use a balloon to dilate the tract, and we use a medical-grade plastic dilator as a trocar for a syringe port. We believe that a single-entry tract through the cortex further reduces the trauma to the parenchyma. The syringe port mounted on the trocar is gently penetrated to allow the brain to adapt and reduce damage to the white matter fibers.
Both microscopes\textsuperscript{2} and endoscopes\textsuperscript{10} have been used to visualize the lesion through a port retractor system. This depends on the surgeon’s comfort level and the size of port used. Even though the endoscope can provide better lighting through the so called flashlight effect, microscopes are in no way inferior to endoscopes in providing adequate lighting.\textsuperscript{7} The recent improvements in microscope technology have made stereoscopic visualization through narrow spaces possible, which has negated the concept of using only microscopes with tubes larger than 20 mm.\textsuperscript{2} We use a microscope for all such lesions. A microscope can provide continuous visualization even during port manipulations. In the majority of cases we use 10-mL or 5-mL syringe ports, whose diameters are 14.5 mm and 12.06 mm, respectively.

The port system made from syringes is a safe and cost-effective replacement for the commercially available tubular brain retractor systems. These ports can be easily used with modern neurosurgical equipment like microscopes and navigation, and the use of standard neurosurgical instruments. Even though these syringe ports may not be superior in sophistication to the commercially available ports, they are equally safe and effective. This would be especially beneficial for neurosurgical setups in developing countries where cost is a constraint to the adoption of newer techniques.

A limitation of this study is the lack of head-to-head comparison with the existing commercial ports in terms of efficacy and safety. Further studies comparing both of these access devices are warranted to validate our conclusions.

\section*{CONCLUSIONS}

Syringe port use as a tubular retractor system for deep-seated brain lesions is a safe, effective, and versatile technique. Such ports can be customized from readily available plastic syringes in a cost-effective manner. Syringe ports, like other commercially available tubular retractor systems, allow smaller tailored craniotomies and adequate visualization of deep lesions, making resection safer.

\section*{REFERENCES}

\begin{enumerate}
\item Bader AM, Rasmussen PA, Bain MD. Initial single-center technical experience with the brainpath system for acute intracerebral hemorrhage evacuation. Oper Neurosurg (Hagerstown). 2017;13:69-76.
\item Norton SP, Dickerson EM, Kulwin CG, Shah MV. Technology that achieves the Triple Aim: an economic analysis of the BrainPath\textsuperscript{TM} approach in neurosurgery. Clinician Outcomes Res. 2017;9:519-533.
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