Emerging technology in intracranial neuroendoscopy: application of the NICO Myriad

Technical note

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Since the beginning of modern medicine, neurosurgeons have tried to find more efficacious and efficient ways to surgically treat intracranial tumors, hydrocephalus, seizures, and many other neurological disorders. Utilizing an endoscope for visual assessment of the ventricular system as well as other parts of the brain is a very old concept. With a unique combination of technological advancements in lens development, charge-coupled devices, and fiber optics, this old concept became a widespread reality in the last 2 decades. The endoscope is now an essential tool of the neurosurgeon and is used alone or in an accessory fashion during microsurgery for the treatment of many different types of intracranial and spinal pathology.

As with all technology, there are limitations in neuroendoscopy that need to be overcome. Depending on the size of a lesion, a purely endoscopic approach for resection may be technically difficult or require significant operative time, given the difficulties with efficient debulking of masses larger than a few centimeters in diameter due to a lack of endoscopic instrumentation. This may lead to abandoning the consideration of an endoscopic approach in favor of a more traditional open procedure. There is a need for technology that works in conjunction with the endoscope for more efficient removal of soft tissue and lesions that otherwise would be more difficult to remove with simple suction and current endoscopic tumor forceps and dissectors.

The NICO Myriad (NICO Corp.) is a recently developed device that is used in multiple intracranial endoscopic procedures for soft-tissue resection. We report on a series of cases involving patients treated between August 2009 and October 2010 with a new device (the NICO Myriad), a non–heat-generating, oscillating, cutting, and tissue removal instrument that can be used through the working channel of the endoscope as well as in open neurosurgical procedures. They used this device in 14 purely endoscopic intracranial procedures and 1 endoscope-assisted keyhole craniotomy. They report that the device was easy to use and found that tissue resection was more efficient than with other available endoscopic instruments, especially in the resection of fibrotic tissue. There were no observed device-related complications. The authors discuss the technical aspects of using this device in endoscopic resection of pituitary tumors, craniopharyngiomas, and colloid cysts. They also demonstrate its use in hydrocephalus and intraventricular clot removal and discuss its potential use in other neurosurgical disorders. (DOI: 10.3171/2011.2.FOCUS10312)

Key Words • hydrocephalus • pituitary tumor • colloid cyst • craniopharyngioma • intraventricular clot • surgical technique
Patient Population and Surgical Device

Patient Population

Between August 2009 and October 2010, 14 patients underwent purely endoscopic intracranial procedures and 1 patient underwent an endoscope-assisted open keyhole craniotomy at the University of Iowa Hospitals and Clinics in which the NICO Myriad was used for various reasons (Table 1). Of these 15 patients, 5 patients had pituitary adenomas, 3 had colloid cysts, 3 had craniopharyngiomas, 2 had loculated hydrocephalus, 1 had a pineoblastoma, and 1 had a tuberculum sellae meningioma.

Surgical System

The NICO Myriad is a minimally invasive surgical system specifically designed for the removal of intracranial and skull-base soft tissues with direct, microscopic, or endoscopic visualization (Fig. 1A–E). The technology platform is based on combining a high-speed reciprocating inner cannula within a stationary outer cannula and electronically controlled variable suction. The instrument relies on a side-mouth cutting and aspiration aperture located 0.6 mm from the blunt dissector end (Fig. 1E). The functions of the device are operated via a foot pedal that allows for precise control of the variable-strength suction and activation or deactivation of the cutting blade (Fig. 1A). The combination of gentle forward pressure of the aperture into the tissue to be removed and suction draws the desired tissue into the side aperture, allowing for controlled and precise tissue resection through the reciprocating cutting action of the inner cannula. In addition to the suction strength being controlled by the graded amount of depression of the foot pedal, the strength can be governed via a knob on the console (Fig. 1A and B). Importantly, the surgeon can immediately stop suction by lifting his foot off the foot pedal (Fig. 1A). This allows the surgeon to observe precisely the tissue that is to be cut and resected and avoid cutting structures drawn into the aperture inadvertently. The aperture can be rotated via a control knob on the handpiece, and the shaft can be gently bent if needed (Fig. 1C). All removed tissue can be captured in the collection chamber (Fig. 1B), which allows for pathological analysis with limited crush artifact from the device.

Unlike ultrasonic devices or laser devices, the Myriad is purely mechanical and generates no heat at the resection site or along its shaft (Fig. 1C and E). It may also be used for spinal tissue or tumor resection in minimally invasive and open surgical approaches. It is a multifunctional instrument that combines the capabilities of scissors, suction, and a blunt dissector (Fig. 1E). The device's low-profile design provides improved access to hard-to-reach tumor sites and better visibility to the surgical field, especially during tumor resection through narrow corridors (Fig. 1B–E). The system is available in a variety of diameters, lengths, and configurations to meet the diverse needs of patients and clinical presentations in intracranial, skull base, and endoscopic procedures. The reusable main console, stand, and foot pedal (Fig. 1A and B) cost approximately $94,000 (US) and the single-use disposable handpieces (Fig. 1C) cost around $2900.

Results and Illustrative Cases

In all cases, the device was easy to use and we found tissue resection to be safe and efficient. There were no observed device-related complications.

Tumor Resection

Neuroendoscopic techniques and approaches are of-

TABLE 1: Summary of clinical and demographic characteristics in patients treated using the Myriad system*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Diagnosis</th>
<th>Approach</th>
<th>Reason for Use</th>
</tr>
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<tr>
<td>1</td>
<td>46, M</td>
<td>fibrous pituitary adenoma</td>
<td>transsphenoidal</td>
<td>tumor resection</td>
</tr>
<tr>
<td>2</td>
<td>31, F</td>
<td>colloid cyst</td>
<td>transcortical</td>
<td>tumor resection, septostomy, intraventricular clot removal</td>
</tr>
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<td>3</td>
<td>74, F</td>
<td>fibrous pituitary adenoma</td>
<td>transsphenoidal</td>
<td>tumor resection</td>
</tr>
<tr>
<td>4</td>
<td>7, M</td>
<td>loculated hydrocephalus</td>
<td>transcortical</td>
<td>cyst fenestration</td>
</tr>
<tr>
<td>5</td>
<td>49, F</td>
<td>craniopharyngioma</td>
<td>transsphenoidal</td>
<td>tumor resection</td>
</tr>
<tr>
<td>6</td>
<td>31, F</td>
<td>colloid cyst</td>
<td>transcortical</td>
<td>tumor resection</td>
</tr>
<tr>
<td>7</td>
<td>27, M</td>
<td>prolactinoma</td>
<td>transsphenoidal</td>
<td>tumor resection</td>
</tr>
<tr>
<td>8</td>
<td>52, F</td>
<td>craniopharyngioma</td>
<td>transsphenoidal</td>
<td>tumor resection</td>
</tr>
<tr>
<td>9</td>
<td>67, F</td>
<td>craniopharyngioma</td>
<td>transsphenoidal</td>
<td>tumor resection</td>
</tr>
<tr>
<td>10</td>
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<td>loculated hydrocephalus</td>
<td>transcortical</td>
<td>cyst fenestration</td>
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<tr>
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<td>tuberculum sellae meningioma</td>
<td>subfrontal craniotomy</td>
<td>tumor resection</td>
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<tr>
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<td>transcortical</td>
<td>tumor resection</td>
</tr>
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<td>tumor resection</td>
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<td>tumor resection</td>
</tr>
<tr>
<td>15</td>
<td>77, F</td>
<td>pituitary adenoma</td>
<td>transsphenoidal</td>
<td>tumor resection</td>
</tr>
</tbody>
</table>

* There were no device-related complications.
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ten considered too difficult for treatment of large intracranial tumors due to prolonged operative time and lack of instrumentation for efficient cytoreduction with acceptable preservation of normal surrounding structures. This limitation spurred the creation of the NICO Myriad, which is designed for working within the limited space provided by the endoscope for efficiently removing intracranial tumors without generating heat or damaging adjacent eloquent brain tissue.

Pituitary Adenoma. In the last 2 decades, the endoscopic endonasal transsphenoidal approach has become a very common procedure for resection of parasellar masses. To make this approach more feasible, microneurosurgical instruments were modified. However, technological limitations still persist. Pituitary macroadenomas are usually soft and friable but have been reported to be fibrous and tough in 5%–13.5% of cases. Fibrous macroadenomas can be difficult to remove with simple suction and ring curettes. We demonstrate an illustrative case in which the Myriad helped remove a fibrous pituitary macroadenoma (Case 7 in Table 1). This 27-year-old man with a history of headaches was found on MR imaging to have a large sellar prolactinoma (Fig. 2A), which became unresponsive to medical therapy and required surgical intervention. The patient underwent endoscopic endonasal transsphenoidal resection of the mass. He had been previously treated with cabergoline, and the pituitary tumor was quite fibrous (Fig. 2C–G). Using standard suction and ring curettes proved to be difficult and time consuming; therefore the Myriad was used for resection (Fig. 2C–G). After centrally debulking the tumor, we were able to quickly shave the tumor off the diaphragma sellae (Fig. 2C–E) without tearing the diaphragma (Fig. 2F and G). In endonasal approaches such as this, the Myriad can be used directly, adjacent to a standard 4-mm endoscope, and without a working channel. It is also compatible with microsurgical endonasal approaches. Gentle bending of the tip can provide additional working angles and trajectories when used with angled endoscopic views. Rotation of the tip via the handpiece dial facilitates direction of the cutting aperture away from critical structures such as the cavernous sinus or internal carotid arteries. Our patient experienced no complications and did well postoperatively; near-total resection of the macroadenoma was achieved, despite the fibrous nature of the tumor (Fig. 2B).

Craniopharyngioma. Craniopharyngiomas are challenging to resect through an open or transsphenoidal approach. Many surgeons have demonstrated successful resection of craniopharyngiomas through an extended endoscopic endonasal transsphenoidal approach. Nevertheless, endoscopic resection of thickened cyst walls and nonfriable tumor tissue can be difficult. We present an illustrative case (Case 5) of a 49-year-old woman who presented with headaches and hormonal imbalance, with MR imaging demonstrating an enlarging sellar and suprasellar cystic and solid mass with extension into the interpeduncular cistern and mass effect on the midbrain (Fig. 3A). She underwent an extended endoscopic endonasal transsphenoidal resection of the tu-
mor (Fig. 3C–F). The solid component and cystic walls required extensive dissection. The Myriad allowed us to quickly debulk the tumor and facilitated capsular dissection. There were no complications, and a complete resection of the craniopharyngioma was achieved (Fig. 3B).

Colloid Cyst. Colloid cysts can be resected through an open or an endoscopic procedure. Many find a purely endoscopic approach to be effective in resection, such that it is often the procedure of choice. Nevertheless, colloid cysts vary in size and consistency, and the cyst contents and walls are often thick and can be difficult to resect using a working-channel endoscope. We have used the Myriad in purely endoscopic resection of colloid cysts. After initial puncture and opening of the cyst, we were able to efficiently remove the often thick or semi-solid cyst contents with the suction and cutting aspects of the device. After central debulking, one can then quickly remove large parts of the cyst wall to facilitate complete excision. This technique can prevent damage to the fornix, as large parts of the lesion are not drawn through the foramen of Monro, and the handpiece aperture can be directed away from the fornix or adjacent veins while in use. Here we present a case of a 31-year-old woman who presented with a 1-week history of nausea and vomiting and was found to have papilledema on physical examination (Case 6). An MR imaging study demonstrated a large mass in the superior aspect of the third ventricle (Fig. 4A). We approached the mass with the endoscope from a left frontal bur hole and initially punctured the cyst (Fig. 4C and D), which allowed us to completely remove the cyst contents with the Myriad (Fig. 4H and I). The suction and cutting aspect of the device allowed us to quickly resect parts of the cyst wall (Fig. 4E–G), and we achieved a complete resection of the colloid cyst (Fig. 4B and J).

Hydrocephalus

The endoscope is used in many cases of obstructive hydrocephalus because a third ventriculostomy can be effective in 70%–80% of these cases. However, cases of loculated hydrocephalus are more complex and challeng-
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Enlarging loculated components of the ventricular system along with trapped ventricles require fenestration to establish communication between these areas and other compartments within the ventricular system that are able to absorb CSF, or to use a single ventriculoperitoneal shunt catheter. These loculated walls are often thick due to previous infection or hemorrhage (Fig. 5A), and creating an adequate fenestration can require a significant amount of time. The Myriad can be used to quickly and cleanly enlarge a fenestration (Fig. 5B). Unlike the usual blunt fenestration techniques, the device’s cutting action produces a smooth edge to the walls of the created fenestration (Fig. 5C). This is illustrated in the case of a 32-year-old woman who presented with bilateral shunt infection/malfunction and a history of loculated hydrocephalus and a supratentorial primitive neuroectodermal tumor in childhood (Case 10). After removal of the shunt systems and antibiotic treatment, we used the endoscope to explore the extensive adhesions within the right and left ventricular systems. The Myriad enabled us to efficiently create a communication between the ventricular systems with large smooth-edged fenestrations, allowing us to place a unilateral ventriculooatral shunt instead of the previous bilateral system. Additional case studies with longer-term follow-up are needed.

**Fig. 3.** Case 5. Craniopharyngioma. A: Preoperative sagittal and coronal contrast-enhanced T1-weighted MR images demonstrating a large enhancing sellar and suprasellar cystic and solid mass with extension into the interpeduncular cistern and mass effect on the midbrain. B: Postoperative sagittal and coronal contrast-enhanced T1-weighted MR images obtained after a purely endoscopic approach, showing complete resection of the craniopharyngioma. C–F: Intraoperative images. A large cystic and solid mass was noted upon opening the sella (C). Myriad-assisted endoscopic resection in and around the optic chiasm (D) provided a complete resection. The Myriad device is shown in open (arrow in E) and cutting modes (arrow in F) removing pieces of the craniopharyngioma.
to determine if such techniques lead to lower recollection or cyst recurrence rates.

Intraventricular Hematoma

Neuroendoscopic evacuation of intraventricular hematomas has been found to shorten the duration of external ventricular drainage. The intraventricular hematoma is often quite thick, making evacuation with suction difficult. The Myriad is able to suction and shave pieces of the clot, enabling a faster removal of the hematoma from within the ventricular system. This is demonstrated in the case of a 31-year-old woman who underwent a purely endoscopic resection of a colloid cyst (Case 2). After the Myriad-assisted complete resection of the cyst, an acute clot formed. We used the Myriad to resect the clot in the lateral and third ventricles (Fig. 6A and B) and create a septostomy. Both foramina of Monro were inspected and found to be patent.

Discussion

The technological advancements made inside the field of neurosurgery are due in large part to advancements made outside the field of medicine. The introduction of the surgical microscope and use of smaller dissecting instruments specifically designed for manipulating tissue around delicate and eloquent brain structures helped make possible what we now know as modern microneurosurgery. For example, laser technology was first introduced to the field of neurosurgery in the 1960s for treatment of intracerebral neoplasms. This technology has evolved into use as a laser scalpel for fenestration of arachnoid cysts, cerebrovascular bypass, and dural reconstruction along with treatment of intracerebral and intraspinal tumors. The use of the ultrasonic aspirator in neurosurgery was first reported in 1978 for the removal of intraaxial and extraaxial tumors and is now a mainstay in intracranial tumor resection. Just as the previous technologies relied...
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Applications of intracranial neuroendoscopy continue to expand as technology improves. Colloid cysts are becoming more commonly treated through purely endoscopic techniques. The anterior skull base is becoming more commonly approached inferiorly through an endoscopic endonasal approach. The extended transsphenoidal approach is gaining popularity for large pituitary adenomas and craniopharyngiomas invading the suprasellar space. Improved techniques for reconstructing the skull base after an endoscopic procedure are making these endonasal procedures more frequent. This has sparked both the need for and the creation of devices for tumor and tissue resection using these minimally invasive approaches.

The working channel of the rod-lens endoscope provides a single avenue for a variety of tools in neuroendoscopic procedures. Instruments, each serving a specific purpose, have been invented to grab, suction, coagulate, cut, or dissect tissue. We report on a device that combines many of those functions into one handpiece that works through the working channel of two commonly used rigid neuroendoscopic systems (Aesculap Co. and Karl Storz GmbH & Co.). The Myriad is a novel device that appears to be of most benefit in resection of thicker tissue that otherwise would be time consuming or impossible to remove with simple suction and dissectors. Its other additional benefits rely on its multifunctional capacity making neuroendoscopic procedures more efficient by combining actions of multiple single-function instruments.

Although the Myriad is the first mechanical device invented for use through the working channel, other instruments have been designed for tissue removal through the working channel, including an ultrasonic aspirator developed and designed specifically for the universal GAAB neuroendoscopic system (Karl Storz GmbH & Co.). Oertel et al. used this device in 2 patients with pituitary adenomas, 2 patients with obstructive hydrocephalus from intraventricular clot blocking the aqueduct, and 1 patient with obstructive hydrocephalus caused by blocking of the aqueduct by a cystic craniopharyngioma. It was effective in all patients without complications. Another instrument used for tissue removal includes a variable-aspiration tissue resection device, which was used in 2 patients with third ventricular hamartomas.

Other Potential Uses of the Myriad System

As endoscopic techniques become more widespread, the trend of minimalism in neurosurgery for less brain retraction and therefore less damage to eloquent brain structures will lead to an even greater use of the endoscope in intracranial lesion resection. The ability to precisely and efficiently remove these lesions depends on the technology developed. Intraventricular tumors and cysts are ideal lesions for the application of neuroendoscopy and resection with assistance of the Myriad system. Other intracranial tumors such as acoustic neuromas may benefit from its precise control. Similar to loculated hydrocephalus, arachnoid cysts throughout the brain or ventricular system are amenable to fenestration enlargement with the Myriad. Elimination of the typically frayed edges of cyst wall fenestrations may prevent future scar development and facilitate a better outcome. It appears that the uses for this device are multiple within intracranial surgery. This capacity for use across disciplines and procedures is important when health care purchasing budgets are limited. As a result, it is likely that the Myriad will become a mainstay and reliable companion in neuroendoscopy.

Fig. 5. Case 10. Loculated hydrocephalus. A: An initial puncture to a ventricular wall created a small fenestration (arrow), which required enlargement with a dilating device. B: We were quickly able to remove the frayed pieces (arrow) of the punctured ventricular wall with the Myriad. C: The suction and sharp cutting aspects of the device allows the fenestration to be quickly and cleanly enlarged, creating a smooth communication (arrow) and preventing possible future scar formation.

Fig. 6. Case 2. Intraventricular hematoma. A: After a purely endoscopic resection of a colloid cyst, an acute clot formed and the Myriad was used for clot evacuation. B: With precise control of suction and the oscillatory cutting action of the device, we were able to quickly suction and remove pieces of the hematoma until it was entirely evacuated.
Summary of Advantages and Disadvantages

In the 15 cases in which we used the Myriad system (Table 1), we experienced or observed the following advantages: precise resection control (controlled tissue resection with the ability to observe tissue prior to cutting and removal through variable-strength suction); the combination of multiple tools in one handpiece (scissors, suction, blunt dissection), making tissue resection more efficient than existing endoscopic instrumentation; rapid control of suction strength with capability of immediate cessation of suction, which enhances safety during intraventricular procedures and around critical structures; notably improved resection speed compared with other purely endoscopic instruments; lack of heat generation; low-profile handpiece, which aids visualization (Fig. ID); compatibility with working-channel endoscopes (Fig. ID); collection of aspirated tissue (Fig. IE) with minimal crush artifact (an advantage for tumor tissue analysis); malleability of tip (up to 30°); and compatibility with both open and endoscopic intracranial procedures.

Disadvantages of the Myriad include the presence of an additional console and equipment in the operating room, the learning curve associated with the device (as with any new device), the lack of hemostatic or cautery capabilities, and the cost associated with the single-use material support: all authors. Study supervision: all authors. Approved it for submission: all authors. Administrative/technical/material support: all authors. Study supervision: all authors.

Conclusions

The Myriad is a minimally invasive surgical system specifically designed for the removal of intracranial and skull-base soft tissues with direct, microscopic, or endoscopic visualization. It is precise in tissue cutting and removal without the use of heat or ultrasonic energy. It is surgeon controlled for real-time variable aspiration for fine-tissue removal. It is effective in efficiently removing fibrous pituitary tumors, craniopharyngiomas, and colloid cysts that otherwise would be technically difficult with standard endoscopic instrumentation, given the consistency of these lesions. It is also effective in enlarging fenestrations for loculated hydrocephalus and removal of intraventricular hematomas. Further uses of this device abound and the Myriad will likely become an important tool in the resection of intraventricular masses.

Disclosure

None of the authors have any financial relationships with or are employed by the NICO Corporation. Dr. Greenlee is a member of an Aesculap, Inc., advisory board.

Author contributions to the study and manuscript preparation include the following. Conception and design: all authors. Acquisition of data: all authors. Analysis and interpretation of data: all authors. Drafting the article: all authors. Critically revising the article: all authors. Reviewed final version of the manuscript and approved it for submission: all authors. Administrative/technical/material support: all authors. Study supervision: all authors.

References

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