Side-Cutting Aspiration Device for Endoscopic and Microscopic Tumor Removal*

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J Neurol Surg B 2012;73:11–20.

Abstract

The authors present a unique side-cutting instrument (NICO Myriad, Indianapolis, IN) with variable aspiration designed specifically for tumor resection. The study included retrospective review of data collected from 10/2009 to 01/2011. We detail the use of the Myriad in 31 patients with the following pathologies: meningioma ($n=16$), chordoma ($n=3$), schwannoma ($n=3$), pituitary adenoma ($n=2$), metastasis ($n=3$), hemangioblastoma ($n=1$), craniopharyngioma ($n=1$), and nasopharyngeal tumors ($n=2$). Surgical approaches included expanded endonasal approach ($n=19$), endoscopic brain port ($n=3$), supraorbital “eyebrow” craniotomy ($n=3$), retrosigmoid suboccipital craniotomy ($n=3$), pterional craniotomy ($n=1$), extreme far lateral ($n=1$), and laminectomy ($n=1$). Successful tumor resection was achieved in 30 cases. Instrument failure was noted in only one extremely fibrous meningioma. The design of this instrument facilitated maneuvering through narrow corridors while providing direct visualization of the suction aperture during tumor resection. These features allowed for tumor removal without injury to adjacent neurovascular structures. The side-cutting aspiration device allows safe and effective tumor removal. Its low profile, variable aspiration, and lack of thermal heat energy are particularly useful in tumor resection through narrow corridors, such as endonasal, port, and keyhole approaches. The multifunctional nature of the instrument (suction, scissors, and dissectors) minimizes multiple exchanges, facilitating tumor resection through these minimal access corridors.

Keywords

- brain tumor
- skull base
- instrumentation
- endoscopy
- microsurgery

In recent years, minimally invasive approaches have been used increasingly to address intracranial tumors. Such approaches include strategically placed keyhole craniotomies, endoscopic endonasal approaches, and more recently transcranial port surgery.^{1–10} This trend has been supported by the improved understanding of skull base anatomy and function-

al anatomy (white matter tractography), the use of intraoperative image guidance, and the development of specialized instruments allowing safe tumor resection.^{11–13} This has led to an effort to reduce the working corridor to minimize collateral tissue disruption.

It should be emphasized that tumor resection through narrow corridors uses the same techniques as those applied in microneurosurgery. Because of the access afforded by minimally invasive approaches, tumor debulking mostly has been limited to suctioning or piecemeal resection techniques.

*This article was originally published online in *Skull Base* on September 16, 2011 (DOI:10.1055/s-0031-1287679)

Although these techniques have proven to be safe and effective, they may be associated to prolonged operative time and, in fibrous tumors the resection, may be challenging.

A critical requirement to facilitate the use of small access corridors is to minimize the reentry of instruments while still maintaining precision and control. This has propelled the development of multifunctional instrumentation that reduces the need for instrument exchange and also reduces the number of instruments in the field at any given time.

In this report we describe the use of a small diameter multifunctional device (suction, aspiration and dissector) that uses a side-cutting variable aspiration technology (NICO Myriad, Indianapolis, IN) to create precision while removing tumors through conventional open skull base approaches. Its multifunctional aspect also facilitates its use in small corridor approaches, such as keyhole supraorbital approaches, the expanded endonasal approach (EEA), as well as the endoscopic port technique.

Methods

Description of Instrument

The Myriad NICO device is a multifunctional instrument, which affords controlled tissue shaving, gross tissue debulking, and blunt dissection. The handpiece is lightweight, weighing 4.2 oz, and is built with a bayonet configuration. It is available in four different cannula diameters: 1.1 mm (19 gauge), 1.9 mm (15 gauge), 2.5 mm (13 gauge), 3.0 mm (11 gauge); and in three different lengths: 10 cm, 13 cm, and 25 cm. The 13-cm is useful for narrow long corridors as those encountered in endoscopic endonasal approaches and transcranial port surgery. The instrument relies on a side aperture, which is located 0.6 mm from the end of the blunt dissector end. The automated functions of the device, namely suction and cutting, are controlled by a foot pedal. When the suction is activated by depressing the foot pedal, tissue is drawn within the side aperture; the strength of the aspiration can be controlled by the foot pedal. Cutting function is also activated by depressing the foot switch and the reciprocating action of the bladed inner cannula transects the tissue that is drawn into the cannula. A key feature is the absence of a rotation blade; this avoids drawing unintended tissue into the aperture. The shaved tissue is suctioned and gathered into a collection chamber. It can also dissect tissue as the fine tip acts as a blunt dissector. Another important feature of the instrument is its ability to be used as stand-alone small bore variable suction that is controlled by the foot pedal. This functionality can be combined with the reciprocating blade to emulate the effect of precise microscissors. The foot pedal allows the user to toggle between these two functions without removing the instrument from the field; therefore, minimizing reentry.

Technique for Usage of the Device

The Myriad NICO device requires the creation of “edges” within the tumor that allows them to be aspirated and engaged into the cannula. The initial technique requires bimanual dissection with microscissors in one hand creating

edges and dissecting and the Myriad device in the other, removing tissue. Alternatively the edges can be created by spreading action of bipolar forceps. As this instrument does not create heat at its tip or along its shaft, heat-related damage to surrounding critical structures is avoided. This facilitates removal of tumor adjacent to critical structures including blood vessels, cranial nerves, and diaphragma sellae. The side-cutting location of the aperture allows (2.5-mm maximum diameter) placement of the instrument's foot plate directly along critical neurovascular structures. The handpiece has a bayonet configuration and its cannula is malleable, which optimizes access and avoids interfering with the endoscopic visualization. Ideally the instrument can be used in one hand allowing for cutting and aspiration function (similar to a suction) while using the bipolar for hemostasis in the contralateral hand to minimize instrumentation within the field and optimize efficiency, that is, creating a “three-handed” effect within the surgical field with a single operator.

The Myriad NICO was used specifically in cases where (1) the tumor consistency was firm, fibrous, and/or rubbery, (2) the tumor was located in close proximity to neurovascular structures, and (3) the tumor was adherent or scarred-in to adjacent tissue due to prior treatments (surgeries, radiotherapy). We specifically assessed extent of safe tumor resection, occurrence of intraoperative neurovascular injury due to the use of the Myriad device, and the incidence of instrument failure.

Results

We accumulated experience with the Myriad device from October 2009 to January 2011 at two institutions, Saint-Johns Health Center (Santa Monica, CA) and The Ohio State University Medical Center (Columbus, OH). The Myriad device was used in 31 patients presenting with meningioma ($n = 16$), chordoma (3), schwannoma ($n = 3$), pituitary adenoma ($n = 2$), intraparenchymal ($n = 2$), and skull base metastasis ($n = 1$), cerebellar hemangioblastoma ($n = 1$), craniopharyngioma ($n = 1$), nasopharyngeal adenocystic carcinoma ($n = 1$), and nasopharyngeal carcinoma ($n = 1$). Surgical approaches used in this series included EEA ($n = 19$), endoscopic brain port ($n = 3$), supraorbital “eyebrow” ($n = 3$), retrosigmoid suboccipital ($n = 3$), pterional ($n = 1$), extreme far lateral ($n = 1$), and thoracic laminectomy ($n = 1$).

Successful planned tumor resection was achieved in 30 of the 31 cases using the Myriad device. Gross total removal (GTR) or near-total removal (NTR) (<95% tumor removal) was achieved in 21 patients. Subtotal removal (STR) (>75% tumor removal) was obtained in nine cases which either presented extension within the cavernous sinus, Meckel cave or beyond in the middle fossa, and/or were residual or recurrent lesions with significant scarring and adhesences due to prior treatments. GTR or NTR was not a realistic surgical goal in any of these nine cases after comprehensive preoperative assessment. One instrument failure was noted during this series with an extremely fibrous planum sphenoidale meningioma resulting in a partial tumor removal with the use of the Myriad device. However, tumor removal proceeded by

piecemeal fashion and an NTR (Case 31). In this clinical series, we encountered no inadvertent vascular or cranial nerve injury or any other intraoperative complications.

We describe the specific intraoperative appreciation of the instrument with three illustrated cases representing application along specific corridor presented. These include a conventional craniotomy (Illustrative case 1), EEA (Illustrative case 2), and endoscopic intraxial port approach (Illustrative case 3).

Illustrative Cases

Illustrative Case 1: Middle Fossa Meningioma through a Subtemporal Approach

A 37-year-old woman presented with progressive seizures as well as documented growth of a left temporal fossa meningioma (►Fig. 1A, B). The patient also had a right frontal meningioma that had been partially removed through a right frontal craniotomy in 1987. The postoperative course required a ventriculoperitoneal shunt. Redo surgery was performed in 1997, and the right frontal meningioma was completely removed. To address the left temporal fossa lesion, a left frontotemporal craniotomy with zygomatic osteotomy was performed. The middle cranial fossa was drilled down to foramen ovale and spinosum as well as the posterior portion of the petrous bone. Given the fibrous texture of the tumor, internal debulking proceeded using the side-cutting aspirator device (Myriad NICO) (►Fig. 1C, D). It was especially useful for tumor removal in proximity to the fifth cranial nerve (V2). A second small meningioma over the orbital roof was also removed. The patient had an uneventful postoperative course with complete tumor resection and no recurrence of seizures (Fig. 1E, F).

Illustrative Case 2: Giant Pituitary Adenoma through Endoscopic Extended Endonasal Approach

A 41-year-old man developed progressive visual loss and documented bitemporal hemianopsia. Brain magnetic resonance imaging (MRI) showed a sellar lesion with suprasellar extension, displacing the optic chiasm superiorly (►Fig. 2A, B). He underwent an endoscopic endonasal surgery in another institution with a subtotal tumor removal. Given that the patient's visual loss and severe chiasm compression persisted, he was referred to our institution for a revision endoscopic endonasal extended transsphenoidal and transplanum skull base approach. Tumor debulking initially proceeded inferiorly with curved microscissors. On the left side, the normal gland was separated from the tumor along a plane offered by a pseudocapsule. Tumor extending into the cavernous sinus, on the right side, was debulked using microscissors. Given the extremely fibrotic and rubbery texture of the tumor, debulking of the tumor within the superior suprasellar space was undertaken using the Myriad NICO (►Fig. 2C, D). This allowed identification on a thin rim of normal pituitary gland to come into view along the left side. Tumor was gently dissected from the descended diaphragma sellae using the Myriad NICO device without the cutter function. Variable aspiration allowed for gentle traction

facilitating blunt dissection. The instrument was used toggling between aspiration alone (to create a clear field and counter-traction) and cutting (to precisely remove the tumor tissue separated from the diaphragma and normal gland). Postoperatively, the patient's vision rapidly improved. Postoperative MRI confirmed the complete removal of the sellar and suprasellar mass with a residual tumor nodule extending along the lateral cavernous sinus and into the middle fossa (►Fig. 2E, F).

Illustrative Case 3: Cerebellar Hemangioblastoma through Endoscopic Transcranial Port Approach

A 68-year-old woman presented with progressive gait difficulties and instability. She had been previously treated for breast cancer with a local lumpectomy and neoadjuvant chemotherapy. An initial contrasted MRI showed a unique right subcortical solitary cerebellar lesion that homogeneously enhanced following the administration of gadolinium (►Fig. 3A, B). An endoscopic transcranial port approach was proposed to remove the supposed brain metastasis. Neuronavigation was used to plan the craniotomy and determine the best point of entrance to reach the subcortical lesion. After a minimal corticectomy, the port was used to cannulate as previously described.¹⁰ The tumor partly delivered itself into the port after removal of the dilator. The tumor was highly vascular and hemostasis was performed using usual microsurgical hemostasis techniques (►Fig. 3C). Resection of the coagulated tumor with scissors was challenging given the fibrous and vascular nature of the tumor. After repeated systematic superficial coagulation, the Myriad NICO was brought into use to shave down the coagulated tissue (►Fig. 3D). Coagulation with an adapted bipolar and resection of this coagulated fibrotic tissue with the Myriad NICO were sequentially repeated. Its multifunctionality for aspiration and cutting proved to be very valuable in this narrow corridor. Intraoperative pathology returned as a hemangioblastoma. The tumor was removed leaving a small residual along a large midline vein (►Fig. 3E, F). The patient had an unremarkable postoperative course with recovery of her gait disturbance.

Discussion

Minimal access corridors are best achieved when a minimal number of instruments are used at any given moment by reducing the need for the exchange of instruments. Concurrently, the surgeon must maintain controlled precision of the instrument while minimizing damage to normal structures. These considerations are also valid for conventional surgical approaches. Despite larger openings at the level of the surface, these exposures most often require working in very narrow corridors between critical neurovascular structures in the depth. In this report we presented a series of illustrative cases to demonstrate these principles for tumor resection in various surgical corridors.

Currently, various ultrasonic aspirators are commonly used to remove brain tumors.¹⁴ Such instruments emit high-frequency vibrations to fragment the tissue, which is subsequently aspirated.^{14,15,16} The addition of a

Figure 1 Preoperative T1-weighted postgadolinium image in axial (A) and coronal (B) planes showing the left middle fossa meningioma. Intraoperative views of the NICO Myriad in use (C, D). The NICO works best along edges created by the microscissors (C) or tissue held under tension with a second instrument (suction) (D). Postoperative T1-weighted postgadolinium image in axial (E) and coronal (F) planes, confirming gross total removal of tumor.

Figure 2 Preoperative T1-weighted postgadolinium image in coronal (A) and sagittal (B) planes showing the invasive macroadenoma, extending to the left cavernous sinus and middle fossa. Intraoperative views of the Myriad NICO in use (C, D). The Myriad NICO works as a multifunctional tool, being used as a suction (C) prior to being used as a dissector and tumor aspirator, removing tumor adherent to the diaphragm sellae (D). Postoperative T1-weighted postgadolinium image in coronal (E) and sagittal (F) planes, confirming planed residual tumor lateral to the cavernous segment of the internal carotid artery.

Figure 3 Preoperative T1-weighted postgadolinium image in axial (A) and coronal (B) planes showing the right subcortical solitary cerebellar lesion. Intraoperative views of the Myriad NICO used through a brain port (C, D). After repeated systematic superficial coagulation (C), the Myriad NICO was used to shave down the coagulated tissue (D). Postoperative T1-weighted postgadolinium image in axial (E) and coronal (F) planes, showing near-total removal of the lesion as a few residual cells were adherent to a large midline vein.

Table 1 Summary of Demographic, Clinical, and Surgical Data of Patients Treated with the Myriad NICO Device

Patient	Age, Sex	Pathology	Approach	Reason for Use of NICO	Tumor Removal	Instrument Failure	Complication
1	71, M	Intramedullary T12-L1 schwannoma	Laminectomy	Tumor, proximity to nerve roots	NTR	None	None
2	60, F	Tentorial meningioma	Retrosigmoid craniotomy and transtentorial approach	Tumor, firm and very fibrous	GTR	None	None
3	37, F	Middle fossa meningioma	Frontotemporal craniotomy with an orbitozygomatic osteotomy	Tumor, fibrous	GTR	None	None
4	78, F	Hemangioblastoma	Suboccipital craniotomy (brain port)	Tumor, fibrous	NTR	None	None
5	68, F	Melanoma metastasis	Frontal craniotomy (brain port)	Tumor	GTR	None	None
6	45, F	Vestibular schwannoma	Retrosigmoid craniectomy	Tumor, proximity to CN and vessels	NTR	None	None
7	65, F	Recurrent invasive pituitary macroadenoma	Supraorbital eyebrow craniotomy, optic canal decompression	Tumor, firm, adherent	STR	None	None
8	67, M	Tuberculum sellae meningioma	Supraorbital eyebrow craniotomy	Tumor, proximity to CN and vessels, adherent	NTR	None	None
9	72, F	Recurrent tuberculum sellae and planum meningioma	EEA/trans tuberculum and transplanum	Tumor, proximity to CN and vessels, scarring	STR	None	None
10	41, M	Brain metastasis, colon primary	Frontal craniotomy (brain port)	Tumor	GTR	None	None
11	32, M	Nasopharyngeal carcinoma	Retrosigmoid craniotomy with suprameatal exposure	Tumor, proximity to CN	STR	None	None
12	35, F	Recurrent atypical CS and Meckel cave meningioma, prior to OR and radiotherapy	EEA/middle fossa and Meckel cave approach	Tumor, proximity to CN and vessels, scarring	STR	None	None
13	35, F	Recurrent progressive atypical CS and Meckel cave meningioma, prior to OR and radiotherapy	EEA/Middle fossa and Meckel cave approach (repeat procedure)	Tumor, proximity to CN, scarring	STR	None	None
13	54, F	Recurrent tuberculum sellae meningioma, prior to OR, radiotherapy, and chemotherapy	Supraorbital eyebrow craniotomy	Tumor, proximity to CN and vessels, scarring, fibrous	STR	None	None
14	41, M	Endocrine Inactive giant adenoma, extension in CS and middle fossa	EEA/trans tubercular (repeat procedure, unsuccessful first attempt elsewhere)	Tumor, proximity of CN and vessels, fibrotic consistency	STR	None	None
15	44, M	Chordoma	EEA/transsellar, transclival, middle fossa approach	Tumor, proximity to CN and vessels, firm and adherent	NTR	None	None

(Continues)

Table 1 (Continued)

Patient	Age, Sex	Pathology	Approach	Reason for Use of NICO	Tumor Removal	Instrument Failure	Complication
16	49, F	Chordoma, prior OR	EEA/transsellar, transclival, middle fossa approach	Tumor, proximity to CN and vessels	NTR	None	None
17	52, M	Recurrent suprasellar, parasellar, and CS meningioma; prior to OR and radiotherapy	EEA/transsellar, transtuberulum, transplanum	Tumor, proximity to CN and vessels, fibrous, scarring	STR	None	None
18	43, M	Adenocystic carcinoma	EEA/inasopharyngectomy middle fossa and Meckel cave, infratemporal fossa, transclival approach	Tumor, proximity to vessel, fibrous	NTR	None	None
19	44, F	Sellar, CS, and clival meningioma	EEA/transsellar, transtuberulum, transplanum, middle fossa approach	Tumor, proximity to CN and vessels, fibrous	STR	None	None
20	56, F	Sellar, CS meningioma	EEA/transsellar, middle fossa approach	Tumor, proximity to CN and vessels, fibrous	STR	None	None
21	49, M	Residual functional macroadenoma with CS invasion, prior OR	EEA/transsellar, middle fossa approach	Tumor, proximity to CN and vessels, fibrous	NTR	None	None
22	37, F	C1-C2 metastasis, thyroid cancer	Carotidovertebral space approach (extreme lateral approach variant)	Tumor, proximity to nerve roots and vessels, fibrous	NTR	None	None
23	42, F	Trigeminal nerve schwannoma	EEA/middle fossa and Meckel cave approach	Tumor, proximity to CN and vessels	NTR	None	None
24	18, F	Craniopharyngioma	EEA/transsellar, transtuberulum, transdorsum sellae, pituitary transposition	Tumor, proximity to CN and vessels	NTR	None	None
25	46, M	Olfactory groove meningioma	EEA/transcribriform	Tumor, proximity to vessels	GTR	None	None
26	49, M	Olfactory groove meningioma	EEA/transcribriform	Tumor, proximity to vessels	NTR	None	None
27	52, F	Tuberulum sellae meningioma	EEA/transuberulum, transplanum	Tumor, proximity to CN and vessels	GTR	None	None
28	57, F	CS, middle fossa, posterior fossa meningioma	EEA/transsellar, quadrangular space, transclival, transpetrous	Tumor, proximity to CN and vessels	GTR	None	None
29	44, F	Chordoma	EEA/transclival	Tumor, proximity to CN and vessels	GTR	None	None
30	40, F	Tuberulum sellae meningioma	EEA/transuberulum, transplanum	Tumor, proximity to CN and vessels	GTR	None	None
31	39, F	Planum sphenoidale meningioma	EEA/transplanum	Tumor, proximity to vessels, fibrous	NTR	Yes (extremely fibrous tissue, NICO did not work)	None

CN, cranial nerve; CS, cavernous sinus; EEA, expanded endonasal approach; F, female; GTR, gross total removal; M, male; NTR, near-total removal; OR, operation; STR, subtotal removal.

programmable suction in most recent systems has maintained an adequate interaction between the tip and tissue minimizing suction-related neurovascular damage.^{16,17} Despite efforts to improve the ultrasonic surgical aspirators, there is still some concerns. Initial studies had reported minimal, though present, collateral damage in the cell layers adjacent to the removal surface.^{18,19} Recent assessments have found that the degree of morphologic damage to the surrounding cerebral cortex increases as the power of the ultrasonic aspirator increases.²⁰ Similarly, disruption of the perineurium, intraneural hemorrhage, endoneural edema, and degenerative changes of the myelinated nerve fibers were seen after use of the Cavitron ultrasonic surgical aspirator system in close proximity to peripheral nerves.^{21,22} The precise mechanism for this potential damage is not yet clear. Furthermore, tumor resection with the ultrasonic aspirators aerosolizes and disperses microscopically intact and potentially viable tumor fragments throughout the operative field.²³ Some authors have proposed that this could potentially contribute to local neoplasm implantation and recurrence.²³ In addition, there is currently a lack of an ultrasonic aspirator that is available for effective port surgery. Although there are ultrasonic aspirators designed for the endoscopic endonasal approaches heat dispersion is a major concern not only for neurovascular injury but also for nasal skin burns.

From this perspective, the side-cutting variable aspirator represents a potential option enabling precise, efficient, and safe tumor resection, especially for firm and fibrotic tissue as described in the illustrative cases. To date, only one case report and two smaller series describe its use, mostly in the context of endonasal endoscopic surgery.^{24,25,26} Our experience with the Myriad NICO has shown it to be a versatile and multifunctional instrument. This instrument was easily maneuvered in conventional skull base approaches (Illustrative case 1) as well as in the keyhole approaches (supraorbital and retrosigmoid), the endonasal endoscopic procedures (Illustrative case 2) and the brain port surgeries (Illustrative case 3). The Myriad NICO device successfully cut and debulked firm, fibrotic, rubbery tumoral tissue such as meningioma and pituitary adenoma (Illustrative cases 1, 2). Furthermore, the advent of the 11 gauge version of the Myriad NICO has enabled a doubling of the tissue removal capacity for particularly fibrotic tumors. It also enabled to cut coagulated tumor tissue facilitating removal of vascular tumor (Illustrative case 3). In this series, only one tumor was too fibrous to be removed by the Myriad NICO (see ► **Table 1**).

In summary, the width of the corridor that is required for tumor removal can be a function of the tumor's fibrosity and vascularity, adjacent neurovascular structures, as well as the surgeon's experience. This instrument enables to address increasingly fibrotic and coagulated vascular lesions. The variable aspiration as well as the lack of heat generated may allow for precise and efficient tumor removal, especially when working along the skull base in close proximity to neurovascular structures or in highly scarred-in and adherent tissue. This potential may facilitate further evolution in minimally invasive approaches both extra-axial and intra-axial (port).

Note

Disclosures: Dr. Amin Kassam is a member of the Scientific Advisory board of NICO Corporation and a consultant for Storz and Stryker.

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