Experience Report

QEVO Micro-Inspection Tool (KINEVO 900 from ZEISS)

Comments

Between September of 2018 and August of 2019, the Micro-Inspection Tool QEVO® from ZEISS was used in 41 cases. 14 major cranial cases are further described in this article. This evaluation with the KINEVO® 900 from ZEISS produced by Carl Zeiss Meditec AG (Oberkochen) took place at the Methodist Hospital in Indianapolis, Indiana. The evaluation was carried out by Dr. Aaron Cohen-Gadol, a neurosurgeon at the Department of Neurosurgery (Indiana University).

Introduction

Description of the setting for this evaluation within the operating room environment

All cases described in this report included use of the KINEVO 900 and the QEVO Micro-Inspection Tool within the operating room during complex cranial procedures. A total of 41 (3 vascular, 31 tumors and 7 others-microvascular decompression surgeries) cases used QEVO, however, the following cases are noted to be of special importance due to their representation of standard complex cranial procedures and the advantages provided by the QEVO Micro-Inspection Tool. A list of these procedures is shown (Table 1). The deep and often narrow operative corridors encountered within these cases and the presence of a portion of the lesions being outside the traditional illumination of a straight light microscope made them exceptional candidates for use of the QEVO Micro-Inspection Tool. Based on the preoperative imaging of these procedures, the QEVO was made available from the start of the procedure to maintain operative efficiency.

Case Type	Pathology	Comments about the use of QEVO
Suboccipital Craniotomy*	Fourth Ventricular Ependymoma	Provide optimized visualization within the floor of the fourth ventricle via the telovelar approach
Right Frontal Craniotomy*	Periventricular Cavernoma	QEVO allowed inspection of the lateral ventricular wall
Retromastoid Craniotomy and Petrosectomy*	Giant Cerebellopontine (CP) Angle Epidermoid extending into the Meckel's cave	Resection of the tumor within the Meckel's cave was only possible under visualization provided by QEVO
Pterional Craniotomy and Extradural Clinoidectomy	Optic Foramen Meningioma	Tumor into the medial foramen was visualizable and resectable without significant optic nerve retraction
Pterional Craniotomy	Suprasellar Epidermoid	Confirmation of tumor removal within the 3rd ventricle
Transtentorial Amygdalohippocampectomy	Medial Temporal Ganglioglioma	QEVO permitted more expanded view of the resection cavity to confirm gross total resection
Pterional Craniotomy	Anterior Communicating Artery (ACoA) Aneurysm	QEVO allowed inspection of the perforating arteries within the operative blind spot
Retromastoid Craniotomy	Hemifacial Spasm	QEVO allowed exclusion of any other compressive vessel in the axilla of the nerve
Retromastoid Craniotomy	Trigeminal Neuralgia	QEVO allowed exclusion of any other compressive vessel in the axilla of the nerve
Retromastoid Craniotomy	Cerebellopontine (CP) Angle Meningioma	Confirmation of gross total tumor resection within the operative blind spots
Supracerebellar Craniotomy	Brainstem Cavernoma	Identification of residual cavernoma and its subsequent resection
Retromastoid Craniotomy	Hemifacial Spasm	QEVO allowed exclusion of any other compressive vessel in the axilla of the nerve
Interhemispheric Craniotomy	Neurocytoma	Resection of the final residual tumor under QEVO guidance
Subtemporal Craniotomy	Meningioma	Confirmation of gross total tumor resection

Table.1. Listing of cases using the KINEVO 900 including pathology and comments regarding the implementation of the QEVO from ZEISS during surgery.

** Indicates cases with further description of experience below.*

Evaluation Report: Operation within the Retromastoid Region

The retromastoid approach, also referred to as the retrosigmoid approach, provides a viewing window parallel to the petrous temporal bone which is ideal for pathology within the posterior fossa adjacent to the cerebellopontine and parapontine regions of the brainstem. These lesions often include: schwannomas, ependymomas, epidermoid cysts, hemangioblastomas, and cavernous malformations. The distribution of the cranial nerves and intricate bony anatomy relative to the surgical approach often complicates straightforward viewing angles toward lesions of interest. Therefore, it is imperative that the surgeon demonstrates technical precision when dissecting lesions within this corridor. Due to the depth of the approach and nonlinear operative working angles, the device that can provide an immediate and practical angled visualization is a welcome addition.

A standard retromastoid approach was utilized for an epidermoid cyst within the cerebellopontine angle. The retromastoid approach provided visualization to permit extraction of the majority of the tumor without significant challenges in visualization. The challenge with this particular lesion was that it had enveloped itself in a bony recess (Meckel's cave) along the petrous temporal bone. A diamond bit was used to drill away a portion of the roof of bone overlying the recess to permit straight light microscopy with the KINEVO 900. However, it became quickly apparent that the lesion had recessed farther than expected within this compartment and therefore the QEVO was necessary to visualize the remainder of the lesion. Under guidance of the QEVO Micro-Inspection Tool, the remainder of the tumor was liberated from its dural attachment with a ring dissector, as demonstrated in Figure 1. The use of the QEVO was especially useful in this case as it allowed tumor resection under direct visualization using a microscope and by inspecting the surrounding structures by using the QEVO.

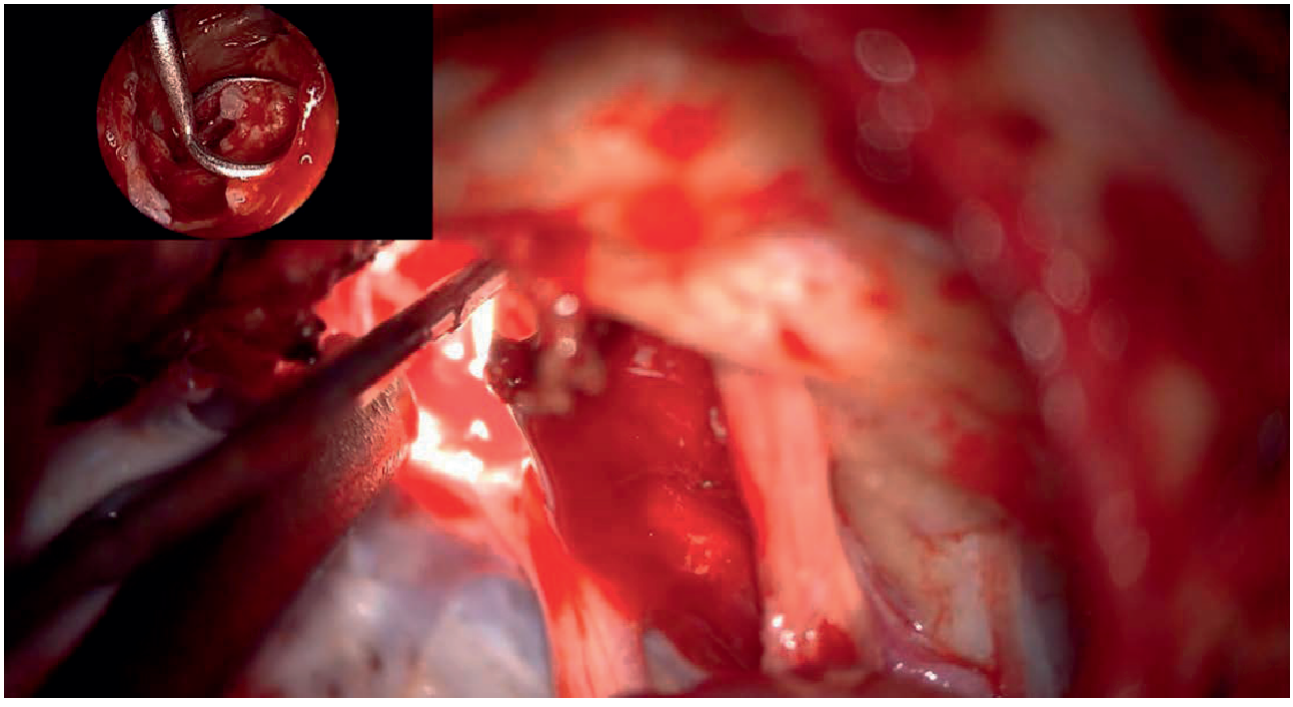

Fig. 1. The 45-degree viewing angle of the QEVO provided an optimized trajectory for visualization of tumor within the Meckel's cave.

Appraisal

The QEVO Micro-Inspection Tool provided an optimized viewing angle for resection of a challenging lesion within the posterior fossa. The ability to utilize this tool on demand during the resection of this complex lesion, surrounded by an intricate web of neurovascular structures, proved indispensable. Straight light microscopy was not sufficient to visualize the residual tumor within the Meckel's cave. The QEVO allowed the surgeon to complete the resection of the lesion under a reliable and efficacious viewing experience. The manipulation of the QEVO was controlled under visualization via the microscope binoculars to make sure that the QEVO did not place any of the adjacent neurovascular structures at risk during its movements.

In summary, the wide viewing angles (100 degree) provided by the QEVO were paramount to the success in resecting this lesion along the cerebellopontine angle. The device was safely positioned and reliably maintained visualization of the region of interest despite a deep working angle and multiple obstructions to straight light microscopy.

Evaluation Report: Operation within the Interhemispheric Trajectory

The interhemispheric transcallosal approach can be tailored for many cerebral pathologies, such as colloid cysts, ependymomas, subependymomas, central neurocytomas, choroid plexus papillomas, and cavernous malformations. This trajectory can be optimized for the tumor of interest through placing the patient's head in a vertical position or in a horizontal position, modified by which hemisphere is in the dependent position. The callosotomy is planned to optimize the trajectory to the lesion but due to the narrow viewing window at the depth of the corpus callosum, visualization and operative working angles within the ventricle are often quite limited.

An interhemispheric transcallosal approach is first undertaken by planning the optimal trajectory to the lesion of interest. After the approach, trajectory has been selected with the assistance of neuronavigation, a craniotomy is performed which overlies the superior sagittal sinus and the ipsilateral region for the approach trajectory. A dural flap is created based on the venous sinus and the dissection along the falx cerebri is performed under straight light microscopy. The corpus callosum is entered transversely to permit access to the frontal horn of the lateral ventricle.

This case involved the approach described above for a cavernous malformation exophytically projecting from the caudate head. Based on the angle of approach from the interhemispheric trajectory, the medial aspect of the lesion was easily exposed, however confirming the resection of the supero-lateral margin of the lesion posed a significant challenge. The QEVO was introduced to allow inspection of the lateral and superior margins of the resection cavity. These regions were not easily visualized using the straight light microscope. Confirmation of complete resection was achieved in this manner.

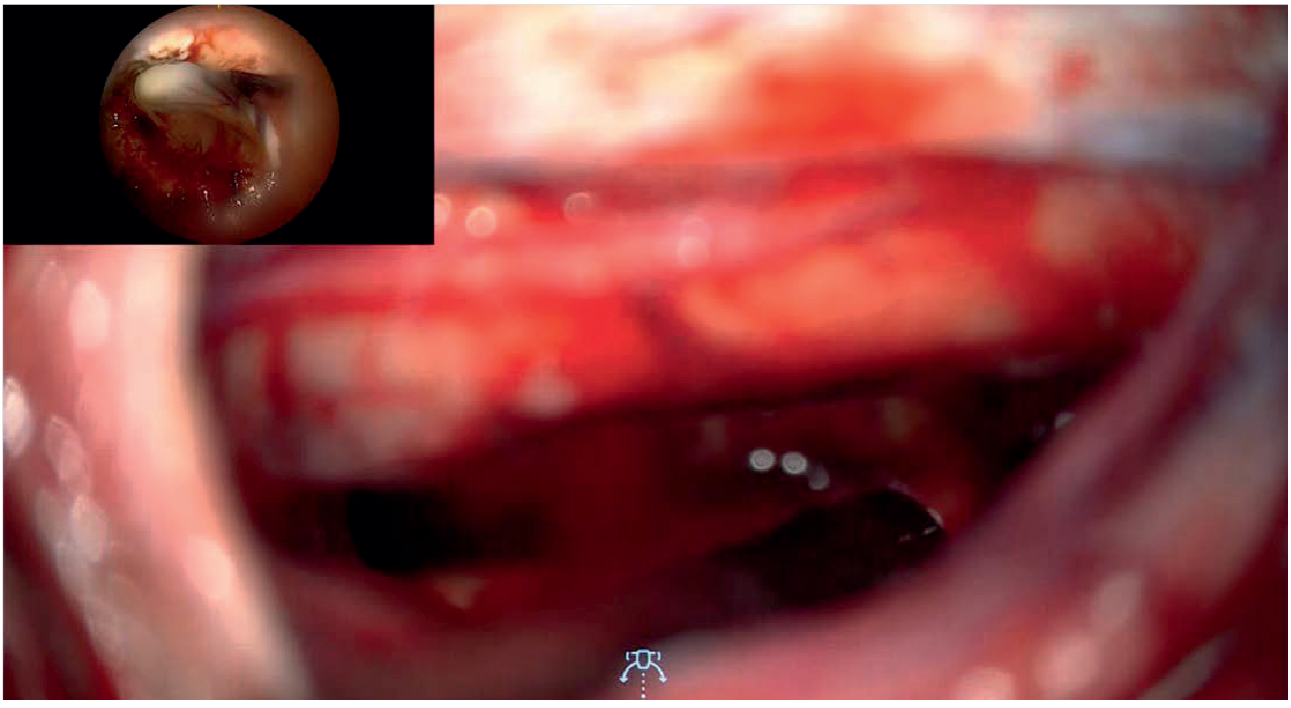

Fig. 2. Through an interhemispheric transcallosal approach, a cavernous malformation presenting along the ependymal surface of the frontal region of the lateral ventricle was exposed. The QEVO provided visualization of the resection cavity despite the challenging viewing angle relative to the approach trajectory.

Appraisal

Visualization of the ventricular system via a keyhole such as the transcallosal approach is particularly challenging. Manipulation of structures such as the corpus callosum and fornix pose significant risks to the patient and therefore intense viewing angles are often limited by a straight light microscope. The QEVO provided an optimized viewing angle to confirm complete resection of the cavernous malformation in the case presented above. The ergonomic design and angulation did not obstruct the transcallosal corridor and proved reliable to avoid adding tension/strain onto the surrounding parenchymal structures during the inspection process. The wide angle optical viewing window (100 degree) allowed for broad field visualization of the resection cavity, which would not have been possible with a standard light microscope.

Evaluation Report – Operation within the Fourth Ventricular Region

Fourth ventricular tumors pose an immense surgical challenge to resection, given the close proximity of eloquent and delicate neurovascular structures, such as the vagal and hypoglossal trigones, facial colliculus, and vestibular areas. Extracting tumor from this region is also challenged by the approach trajectory required to visualize this area. The vermis of the cerebellum and superior medullary velum serve as the roof over the fourth ventricle that requires manipulation to adequately visualize this area. Often a telovelar approach is necessary through which the straight light microscope exposes the contents of the fourth ventricle to the observer.

In this example case, the telovelar approach utilized a suboccipital craniotomy to facilitate the viewing angle into the fourth ventricle. The cerebellar vermis was retracted superiorly to further expose the fourth ventricular floor.

The lesion in this patient was a fourth ventricular ependymoma which extended both rostral and caudal to the fourth ventricular floor. This patient underwent resection. The approach described above provided excellent visualization of the caudal extent of the lesion but some difficulty was experienced during the pursuit for the portion of the lesion extending rostrally adjacent to the cerebral aqueduct. Following extensive dissection, the QEVO was used to provide confirmation of complete resection and evaluate the cerebral aqueduct to confirm patency after removal of the tumor.

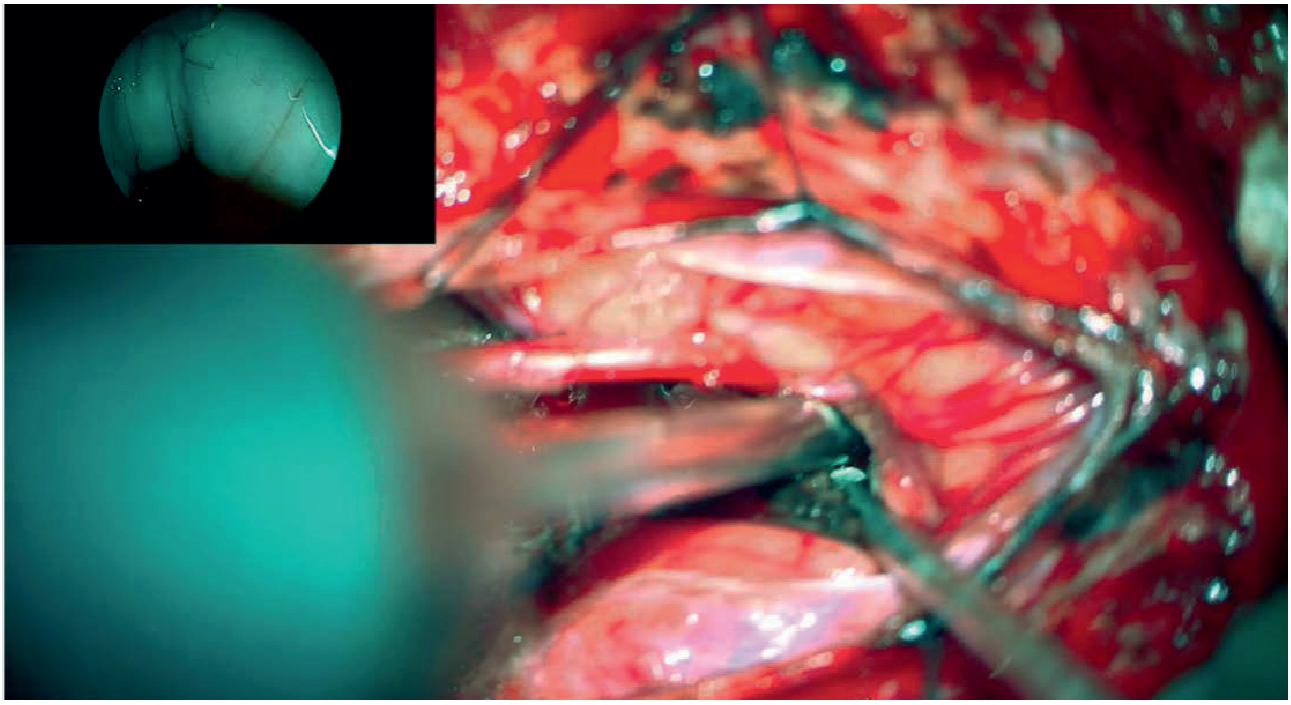

Fig. 3. The telovelar approach was utilized to provide a viewing window into the rostral fourth ventricle. The QEVO was used to visualize the superior medullary velum and cerebral aqueduct to confirm patency and complete resection of the lesion. This avoided further injury to the vermis via the transvermian approach.

Appraisal

The amount of cerebellar vermis retraction necessary to achieve visualization of the superior medullary velum and cerebral aqueduct is often extreme and risks injury to the vermis with potentially devastating neurologic consequences. The QEVO allowed for a much safer and more optimized viewing angle than standard straight light microscopy could have permitted. It also avoided the need for excessive cerebellar retraction during the inspection process. Therefore, when rostral fourth ventricular visualization is necessary, visualization should be first attempted via the QEVO to avoid excessive cerebellar retraction and confirm absence of tumor within this potential recess.

Conclusions

The QEVO provided a novel perspective on a multitude of cranial pathologies. The ergonomic design and fast set-up with the KINEVO 900 system make this an efficient tool for use as needed by the microneurosurgeon. The complexity of deep operative corridors, such as in the posterior fossa and ventricular space, often manifests through acute angles and "blind-spots" during straight light microscopy, which limits the surgeon's ability to accurately survey the surgical field.
The QEVO Micro-Inspection Tool should be a critical component of the surgeon's armamentarium to expand visualization within challenging surgical exposures because of the wide viewing angle (100 degree) provided.

The image quality and the depth perception provided by QEVO was excellent and provided high-resolution viewing of the neurovascular structures. No safety concern is noted. The advantages of QEVO over the standard endoscopes include the ability to use the QEVO readily at any time on-demand without prior preparation and without bringing the endoscope tower into the OR. The ergonomic handle of the QEVO is another nice advantage. Unlike the long handle of traditional endoscopes, the manipulation of the QEVO's handle can be controlled under visualization via the microscope binoculars to make sure the QEVO does not place any of the adjacent neurovascular structures at risk during its movements.

The QEVO Micro-Inspection Tool is designed as an inspection tool to complement the microscope view. It has been developed for the optimal use in combination with a surgical microscope supporting its use without repositioning the microscope head. With the ergonomic handpiece and relatively short length, QEVO allows one to look at anatomical structures around corners. It is not optimized for pure endoscope treatments. The major difference lies in the absence of a working channel and specifically designed endoscopic instruments. The QEVO Micro-Inspection Tool does not require a time consuming set-up as it is designed to be a plug-and-play autoclavable solution. This difference is important to be acknowledged.

Overall, the QEVO Micro-Inspection Tool is most beneficial in the following cases:

- The deep and often narrow operative corridors encountered within deep-seated lesions and the presence of a portion of the lesion being outside the traditional illumination of a straight light microscope
- The depth of the approach and nonlinear operative working angles (ventricular and CP angle surgery)
- Resection of lesion under direct visualization using the microscope and by using the QEVO to inspect the cavity is possible and was proven in our series of 14 complex cranial procedures.

We appreciate this opportunity from Carl Zeiss Meditec to evaluate this novel tool.

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