Experience Report
KINEVO® 900 from ZEISS

Comments
On November 14 and 15, 2016, the prototype evaluation of the newly developed Robotic Visualization System™ – KINEVO® 900 from ZEISS produced by Carl Zeiss Meditec AG (Oberkochen) took place at the Anatomical Institute of the University of Regensburg. The surgical-technical evaluation was carried out by Prof. Dr. med. Karl-Michael Schebesch and Dr. med. Julius Höhne, both doctors at the Department of Neurosurgery (University Medical Center of Regensburg). For a short period of time, the head of the department, Prof. Dr. med. Alexander Brawanski, was also present.

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Introduction

Description of the technical environment/description of the cadavers

At the Anatomical Institute logistics and spatial relations were optimal for the surgical technical evaluation. All surgical instruments were available (e.g. electric Trepan, osseous saw, instruments, expendable items) to create a realistic simulation of the surgical approaches. The operations were performed on an anatomical section table; illumination was provided by the light of the Robotic Visualization System – ZEISS KINEVO 900. Delivery, setup and connection of the components were carried out exclusively by employees of Carl Zeiss Meditec AG.

Fig.1. Setup in the dissection room: with ZEISS KINEVO 900, 4K 3D monitor and TRENION 3D HD.

The procedures were captured in video recordings, either via the integrated camera of KINEVO 900 or via handheld cameras. The examined cadavers were all deep-frozen human heads. On both days 10 cadaver heads were evaluated and then refrozen. Each head was taken out of the freezer 24 hours prior to examination, allowing adequate thawing time at room temperature. On the preparation, some icy patches were encountered, however the bony structures and cerebral membranes were intact. Cranial nerves were in a very good state and comparable with in vivo findings. Even though bloodless, pre-paration of vascular structures was authentic. The parenchyma of the brain of all specimens appeared clearly atrophied and partially liquefied. However, there was a wide variation in the state of preservation. In all approaches that are mainly intraparenchymal (above all the transcallosal approach) only well preserved specimens were chosen. Once the ventricular system was entered, all anatomical structures could clearly be visualized.

Fig. 2. Cadaver after right frontal craniotomy (for transcallosal access)

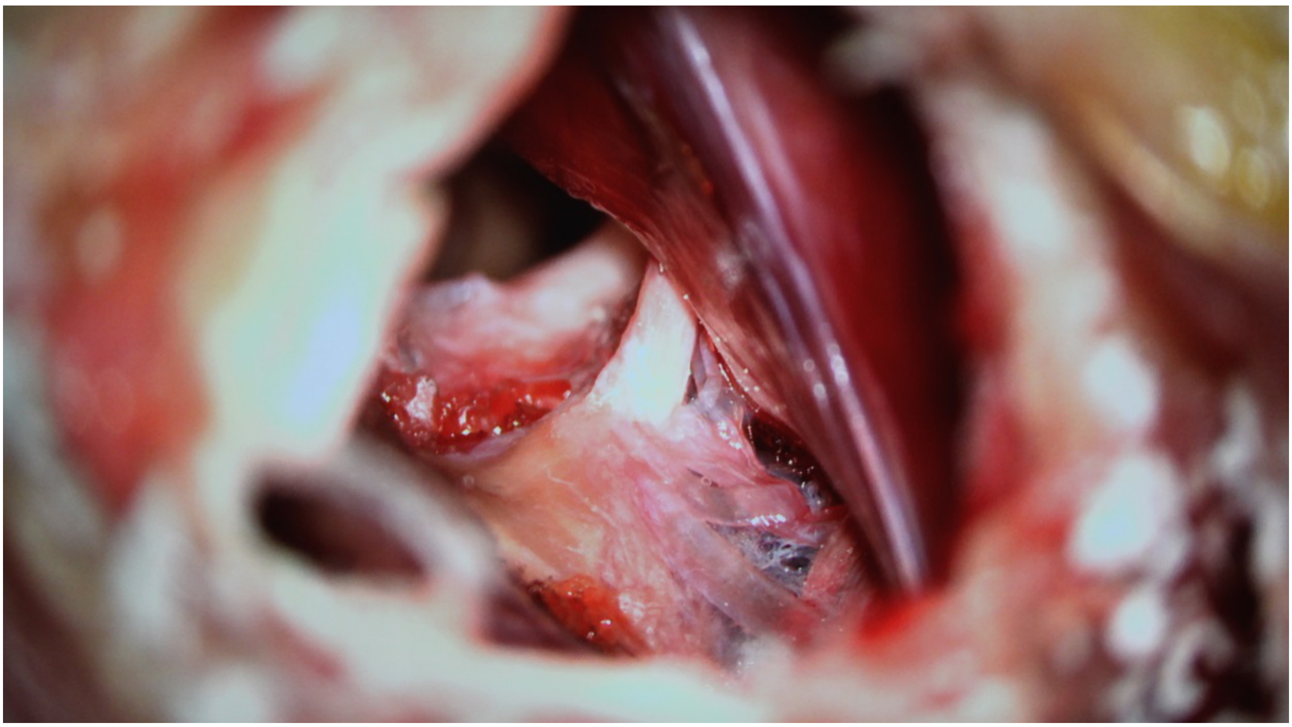

Fig. 3. View from ZEISS KINEVO 900 (retrosigmoid approach)

Evaluation Report

Operating on the ventricular system (transcallosal approach)

The transcallosal approach allows the visualization and manipulation within the lateral and third ventricles. Operations in these central regions of the brain are necessary for tumors (e.g. choroid plexus papillomas, colloid cysts, ependymomas), but also for occlusive hydrocephalus (e.g. atresia of the foramen of Monro, stenosis of the cerebral aqueduct, following meningitis).

This craniotomy is situated around the coronal suture; two thirds of the 6–7 cm bone flap are in front and one third behind. The Dura is opened in a trap-door fashion based on the sagittal sinus; this enables a microscope view parallel to the falx cerebri. Falx and the ipsilateral hemisphere are then gently retracted. Finally, the corpus callosum can be readily identified by its glistening white pallor and is entered in the midline through a minimal opening. The ventricle is reached approx. 1.5 cm later.

Ideally, the ventricle is entered at the cella media, the central part of the lateral ventricle. This approach facilitates access to the frontal horn (Cornu anterius), posterior horn (Cornu posterius) with the choroid plexus, in addition to exposure of the third ventricle through the foramen of Monro. Other, relevant structures located around the lateral ventricles are the fornices, thalamostriatae vein and basal ganglia (Thalamus, hypothalamus, Caput of caudate nucleus).

Appraisal

This approach was performed on 3 cadaver heads. Every time, QEVO® from ZEISS was introduced after callosotomy (dissection of the corpus callosum). QEVO allowed visualization and illumination of the convoluted lateral ventricle anatomy and generous exposure of all surgically relevant structures. The small shaft diameter of QEVO of about 3.6 mm enabled easy and atraumatic passing through the foramen of Monro. The visualization of the very narrow third ventricle, looking at the mammillary bodies and at the tip of the basilar artery, was excellent.

In summary, visualization and handling of QEVO were very useful extensions of the microscopic view provided by ZEISS KINEVO 900 for the transcallosal approach and the intraventricular inspection. The important aspect here is that the insertion of QEVO, and movements during inspection have not led to any accidental injury of the very vulnerable structures – due to its angled design and ergonomics. Of particularly favorable note is the 45° optic of QEVO, enabling a wide view of the ventricular plane, a feature not available with microscope illumination alone.

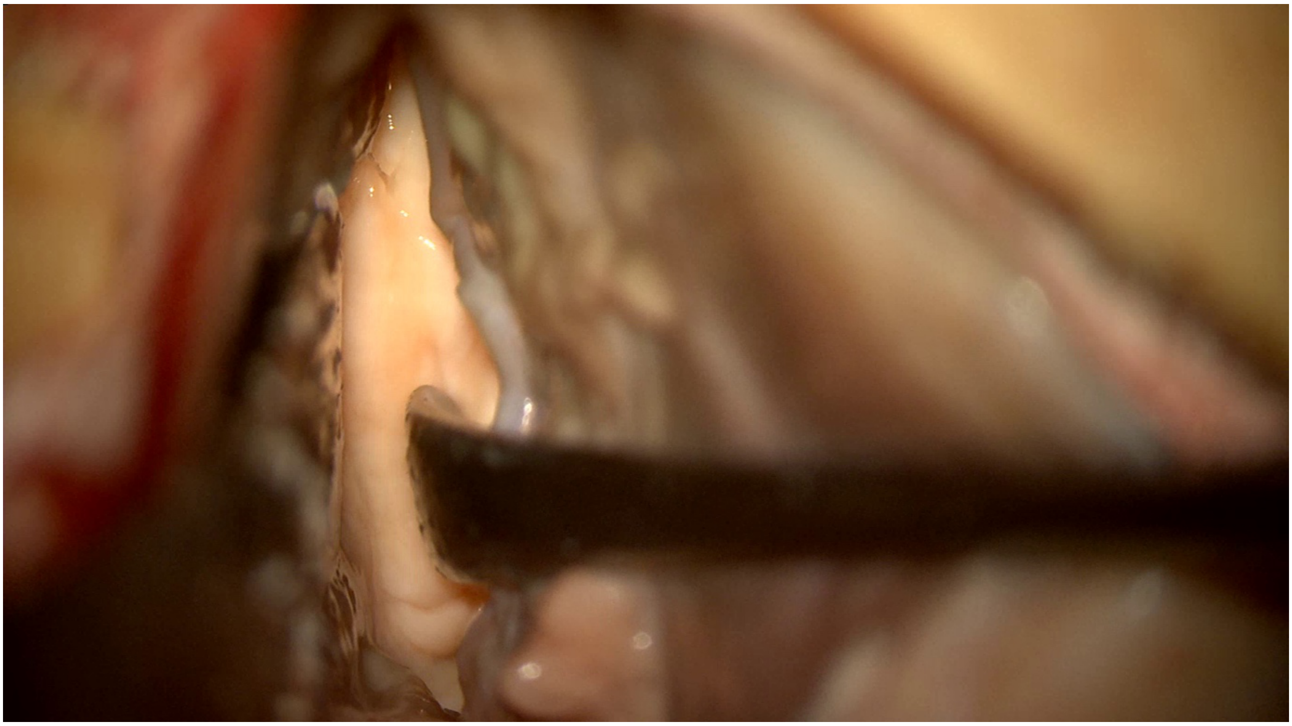

Fig. 4. View from ZEISS KINEVO 900 – Corpus callosum

Fig. 5. View from ZEISS KINEVO 900 – Callosotomy and opening of the lateral ventricle

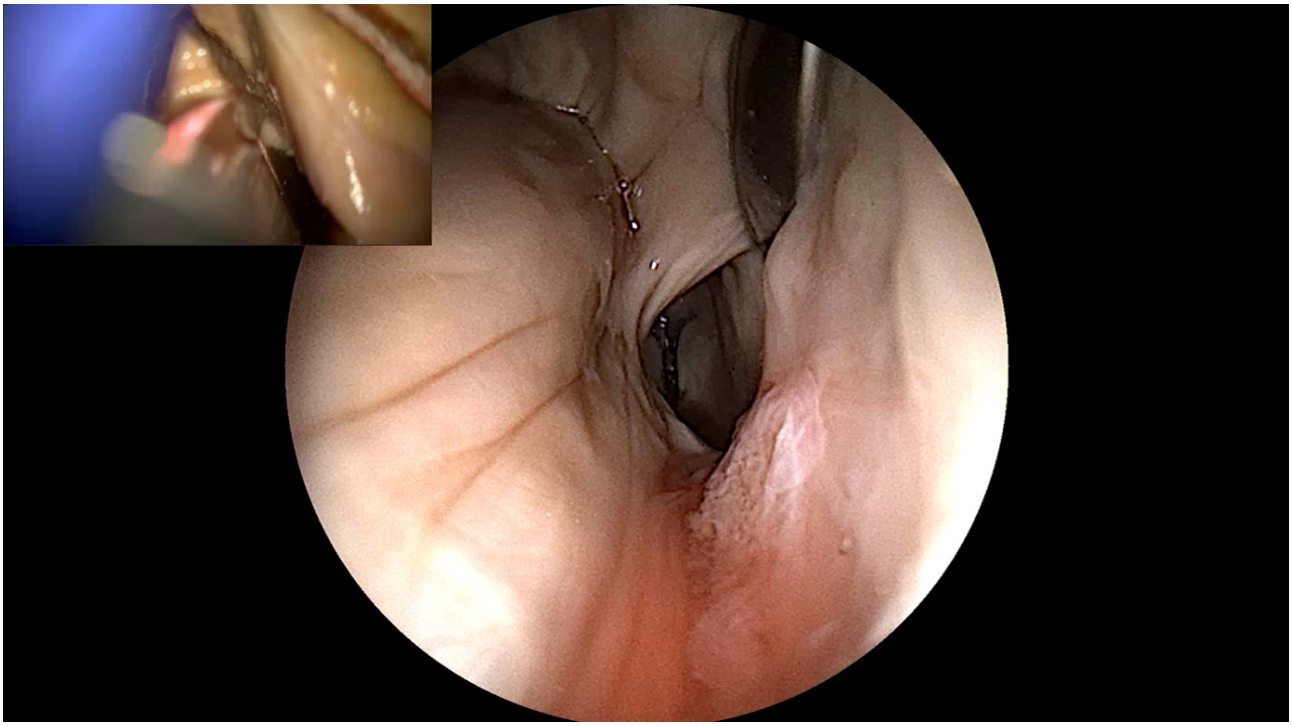

Fig. 6. View from QEVO – lateral ventricle and foramen of Monro with a simultaneous view from KINEVO 900 (top left corner picture)

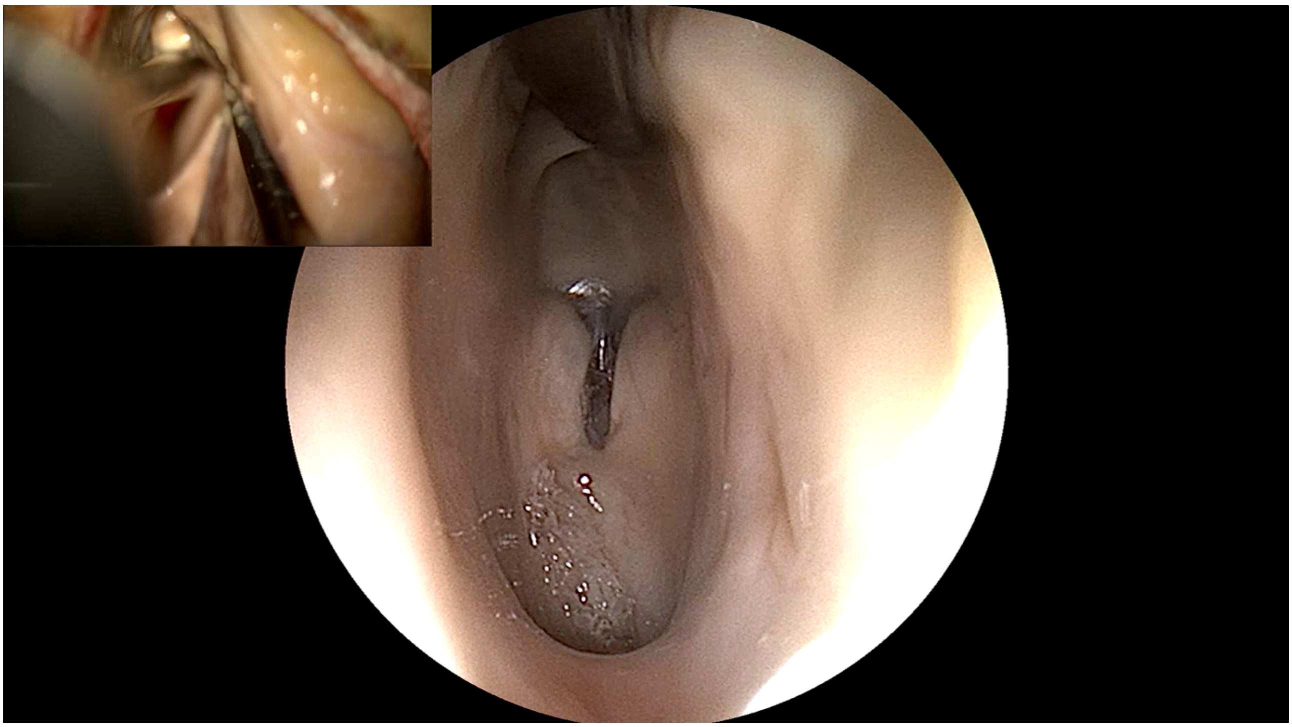

Fig. 7. View from QEVO – 3rd ventricle (after entering foramen of Monro) with a simultaneous view from KINEVO 900 (top left corner picture)

Operation within the cerebellopontine angle (retrosigmoid approach)
Tumors arising in the cerebellopontine (CP) angle are mostly neurinomas of cranial nerves, most frequently of the vestibulocochlear nerve (acoustic neurinoma). Other entities arising from the CP are Epidermoid tumors, metastases, meningiomas, and others. Approaching the CP is demanding and requires a thorough understanding of the anatomy as well as the operative routine. Any technical aid allowing the surgeon “to see around the corner,” to look underneath vessels and nerves (primarily into the auditory canal) and to penetrate small cisterns or spaces which aren’t amenable with the microscopic view, is welcome.

Behind the ear, directly above the so-called mastoid groove, the skin is incised for approx. 8 cm in an almost linear fashion. Below the junction of the transversus sinus and the sigmoid sinus, a craniotomy approx. 2–3 cm wide is placed. Once the dura is opened under view of the ZEISS KINEVO 900 the lateral part of the cerebellar hemisphere is revealed. Opening of the cisterna magna at the level of the foramen magnum will release cerebrospinal fluid to permit greater relaxation of the posterior fossa contents and better retraction of the cerebellum. The cerebellum is gently pushed medially with the self-retaining retractors to gain access to the CP. Depending on the required corridor, the approach can be extended upwards (in the direction of the tentorium) or downwards (in the direction of the base of the posterior fossa). The following structures can be accessed: The cranial nerves N. V (trigeminal), N. VI (abducens), N. VII (facial), N. IIX (vestibulocochlear), N. IX (glossopharyngeal), N. X (Vagal), N. XI (accessory) and N. XII (hypoglossal). Furthermore, one gains access to the cerebellar arteries (posterior inferior cerebellar artery, anterior inferior cerebellar artery, labyrinthine artery, basilar artery as well as to the vertebral artery). Moreover, the brain stem, the foramen magnum, the jugular foramen, the hypoglossal canal, the internal auditory canal and the underside of the tentorium can be approached.

Appraisal
This approach was performed on 5 cadaver heads, 4 of which were well preserved in terms of tissue consistency; also, all vascular and nerve structures were well preserved. QEVO allowed excellent unilateral visualization and examination of posterior fossa content. The visual resolution was that good that even fine nervous branches of the accessory could be identified. Besides, a key advantage of QEVO was the view below the N. IIX, towards the N. VII and following the nerve on its way into the internal auditory canal. This view is not possible with the outside view of KINEVO 900. This is an essential aspect of the surgical management of acoustic neuromas.

Also, depiction of the trochlear nerve which pierces the dural edge of the tentorium cerebelli was easily possible. Identification of tentorial bridging veins using ZEISS QEVO is helpful, because often these cannot be seen under the microscopic view, and often bleeding from these veins occurs after mobilization of the cerebellar hemisphere (through accidental tear of the veins).

In summary, use of QEVO as a complement to KINEVO 900 in the CP and the medial part of the tentorium is very valuable, particularly because of its 45° optic. This has the potential – after an individual learning curve – to make operations shorter and safer.

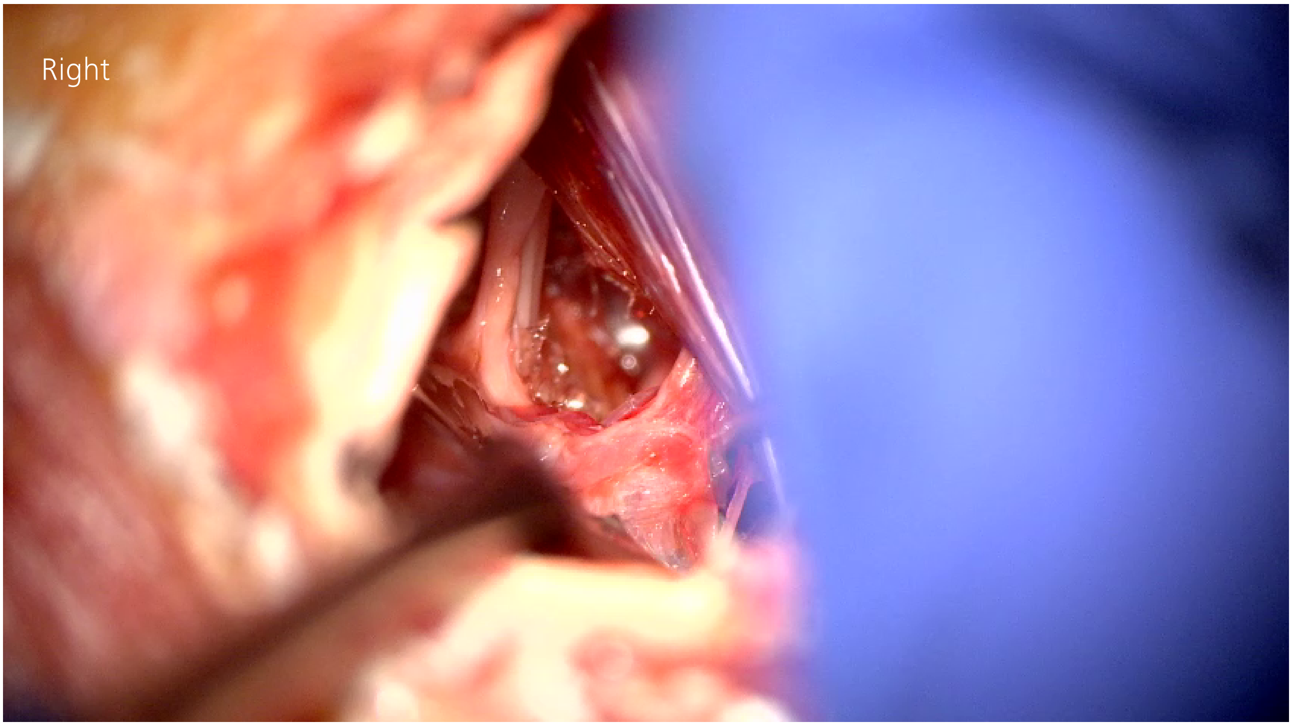

Fig.8. View from ZEISS KINEVO 900 – cranial nerves N.VIII und N.IX-XII

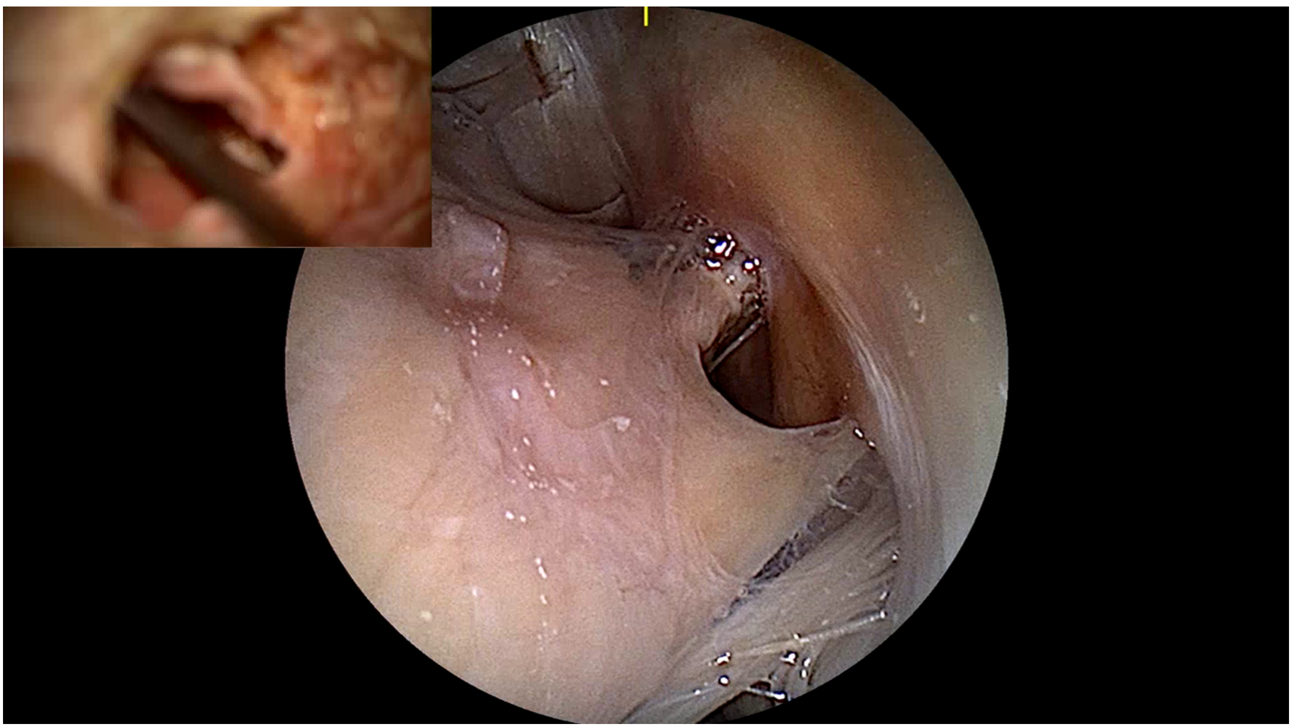

Fig. 9. View from QEVO – Internal auditory canal with cranial nerves N. VII/IIX and jugular foramen with N. IX-XI with a simultaneous view from KINEVO 900 (top left corner picture)

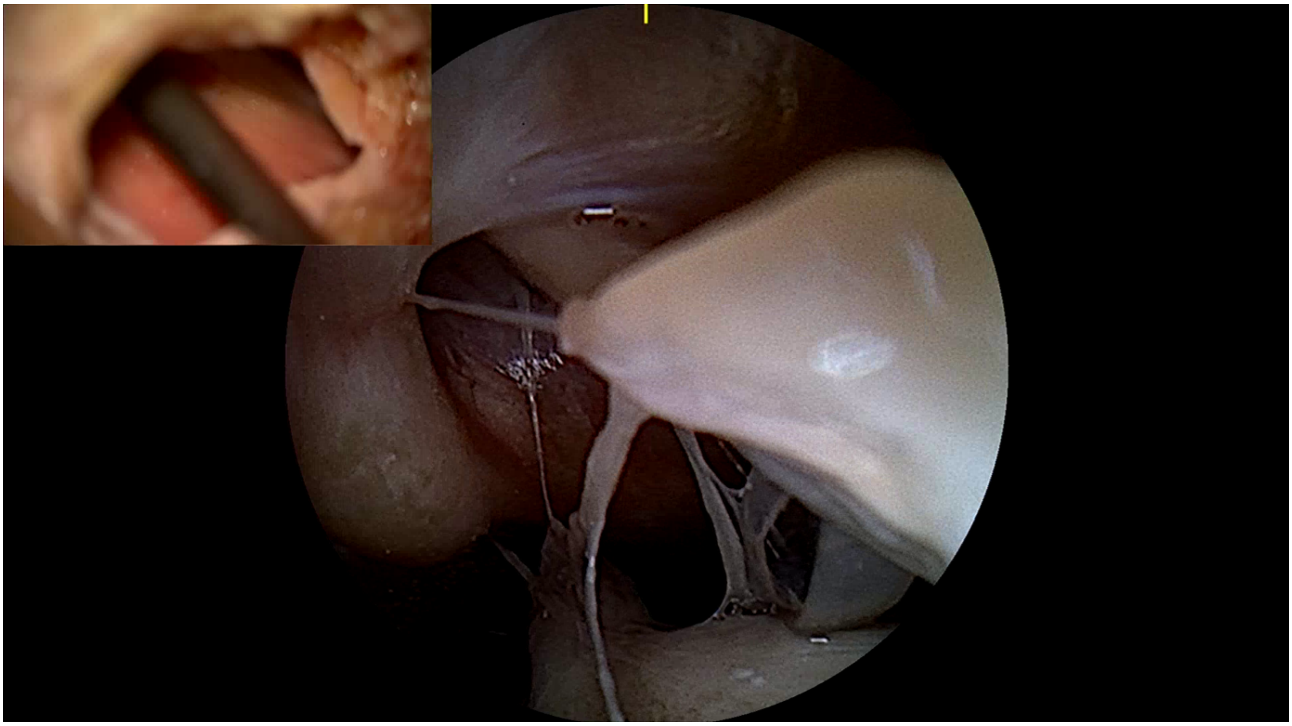

Fig. 10. View from QEVO – following the cranial nerve N. IIX into the internal auditory canal with a simultaneous view from KINEVO 900 (top left corner picture)

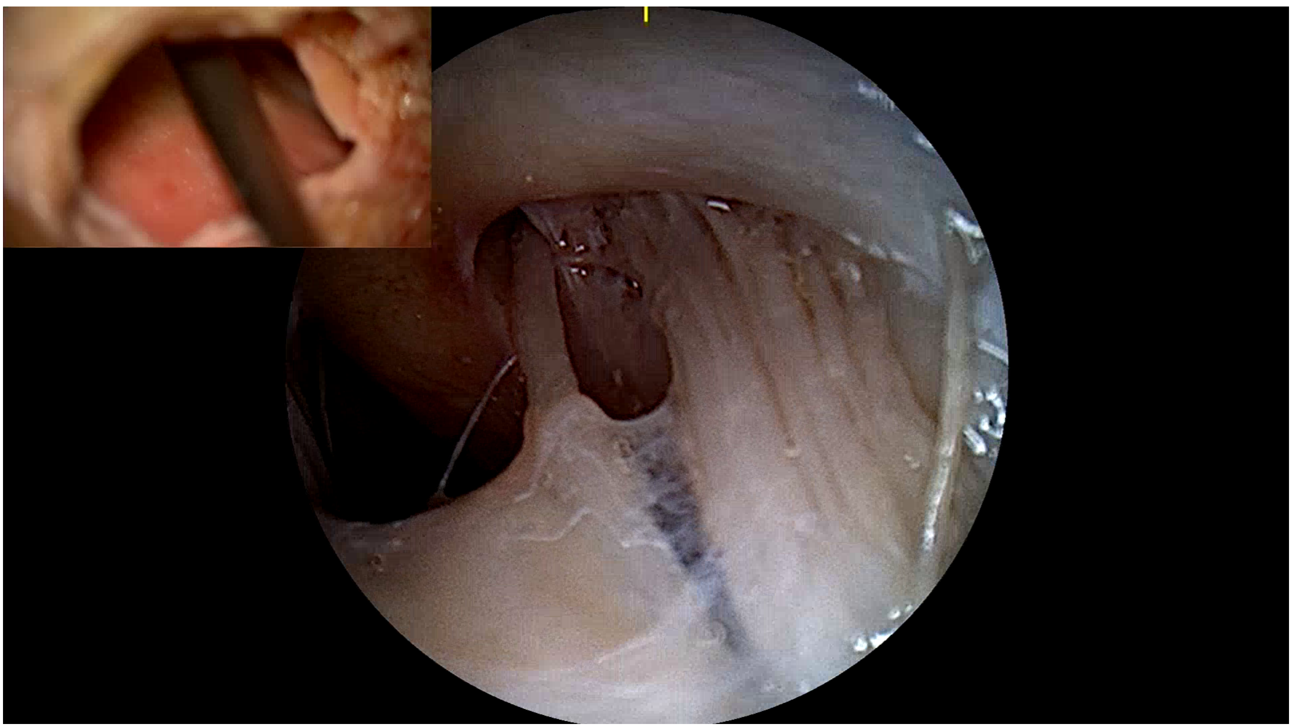

Fig. 11. View from QEVO – jugular foramen with a simultaneous view from KINEVO 900 (top left corner picture)

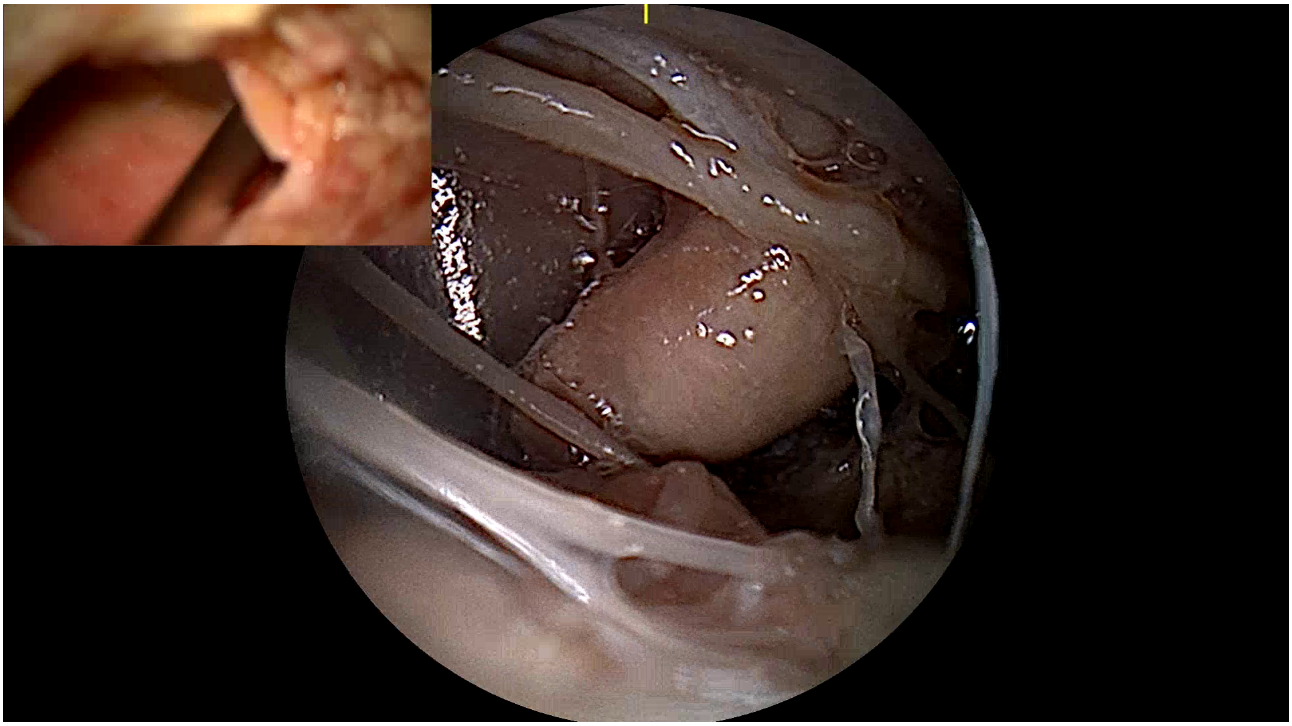

Fig. 12. View from QEVO – vertebral artery and caudal cranial nerves with a simultaneous view from KINEVO 900 (top left corner picture)

Operation within the para- und suprasellar region (pterional approach)
The pterional approach is the workhorse of the supratentorial approaches. Through this corridor a unilateral surgical route is created to the anterior skull base, frontal and temporal lobe, as well as the retro- and parasellar region. The cranial nerves I-VI (olfactory, optic, oculomotor, trochlear, trigeminal/ophthalmic, abducens) are located here. And also the anterior vascular complex (carotid artery, middle cerebral artery, anterior cerebral artery, anterior communicating artery) and the pituitary stalk.

Tumors of the skull base, pituitary tumors (e.g. craniopharyngeomas, Rathke's cleft cysts) and 80% of all aneurysms can be found here.

The skin is incised behind the hairline from the midline to just in front of the ear, the jaw muscle is then mobilized from directly behind and next to the eye, a bone flap of variable size is removed. After opening the dura, the frontal and temporal lobes are exposed, separated by the frontotemporal sulcus (sylvian fissure). Now the frontal lobe is carefully elevated from the anterior skull base and held up by self-retaining retractors. The optic nerve is identified next and the surrounding cistern containing cerebrospinal fluid opened to alleviate pressure and reduce the cerebral volume. Lateral to the optic nerve and the optic chiasm is the internal carotid artery which then divides into the middle and anterior cerebral arteries.

Appraisal
This approach was performed on four cadaver heads. Nervous and vascular structures were very well-preserved so that this approach could be simulated with ease.

QEVO allowed an impressive view between both optic nerves and below the optic chiasm. This is pleasantly surprising for the microscope-trained eye and all the more important, since remaining tumor tissue of tumors arising from the sphenoid plane or the pituitary is often located below the chiasm and concealed from direct view. Also, the often cumbersome task of gaining a perspective of the frontal curvature along the temporal skull base was straightforward with the 45° optics in all four simulations.

In summary, within the scope of the enlarged visualization of para-, supra- and intrasellar (apical) structures, complementing the view from KINEVO 900 with ZEISS QEVO is particularly helpful because of the good viewing angle and is thus a versatile and dependable tool. It is quite conceivable that QEVO could be useful in judging the operability of aneurysms.

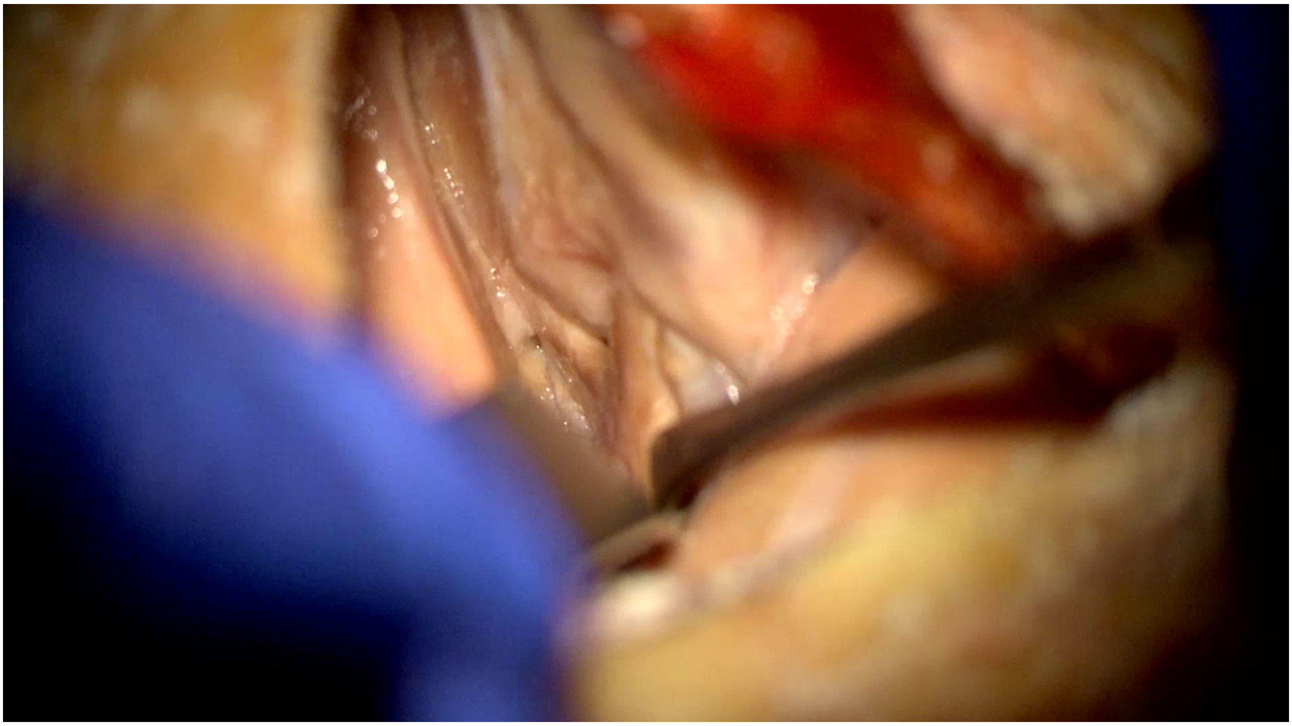

Fig. 13. View from ZEISS KINEVO 900 – looking at the optic chiasm and right optic nerve

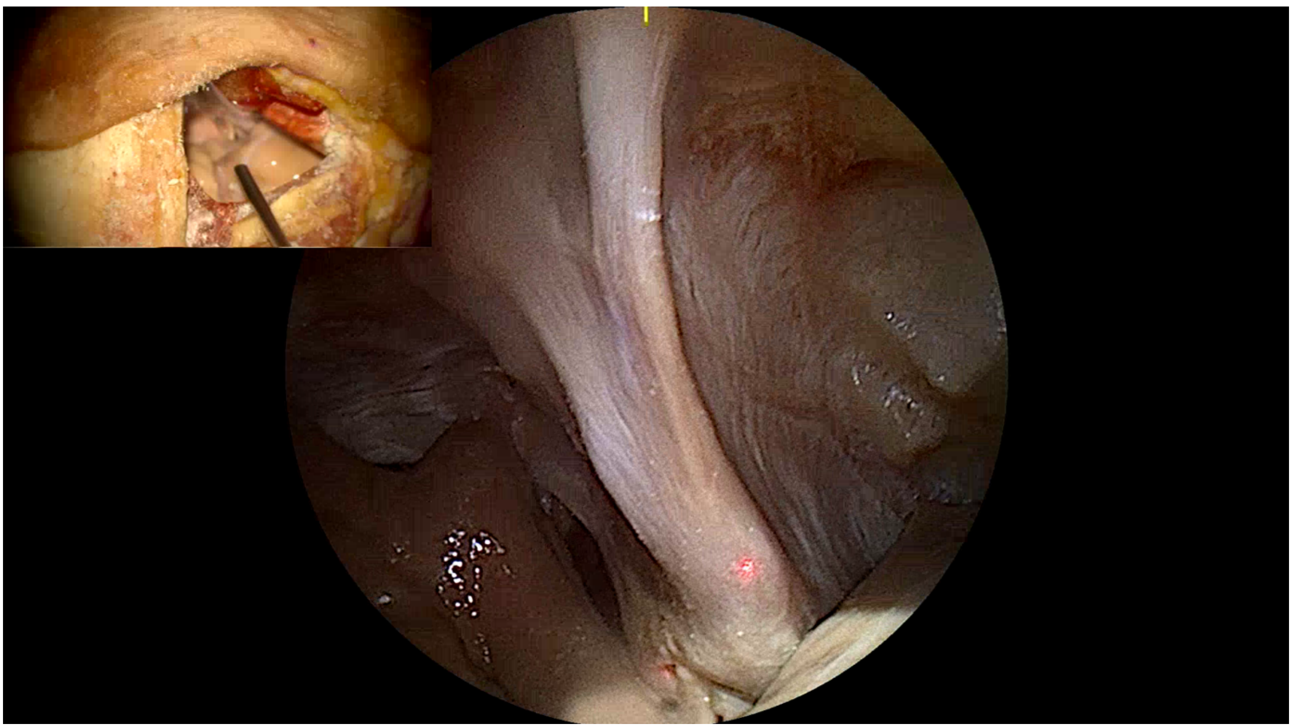

Fig. 14. View from QEVO – sphenoid wing, frontal and middle skull base with a simultaneous view from KINEVO 900 (top left corner picture)

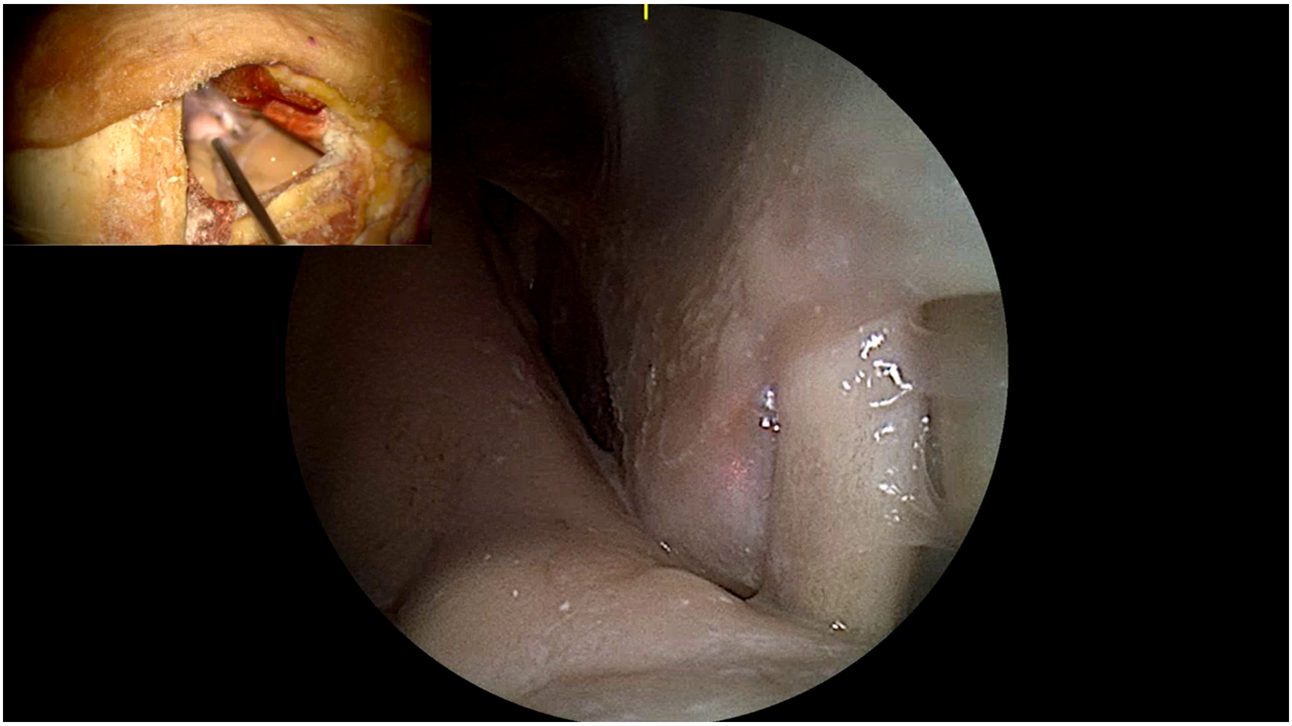

Fig. 15. View from QEVO – optic nerve entering the optic canal with a simultaneous view from KINEVO 900 (top left corner picture)

Operation within the intrasellar region (transsphenoidal approach)
The transsphenoidal approach is the standard route to the hypophyseal fossa and is, apart from few exceptions, mainly used for the resection of pituitary adenomas. These operations are mainly performed by a neurosurgeon, but sometimes, as part of an interdisciplinary approach, together with endoscopy-experienced colleagues of the ENT department.

After disinfection of the nose, one nostril is entered with QEVO transnasally and the natural ostium (entrance) of the sphenoid bone cave is exposed and extended so that the endoscope and another instrument can be comfortably passed through. The protruding (and often thinned out) floor of the sella turcica can be found on the roof of the sphenoid sinus. Small bony septa of the sphenoid sinus are opened and removed to preserve the view at the sella, passing optic nerves and both internal carotid arteries. The final step is to open the floor of the sella, as well as the capsule of the pituitary gland and remove the adenoma in a piecemeal fashion with small curets.

Appraisal
The handling of QEVO in the nasal head cavity was extremely good. For this approach, traditionally 30° optics are used, nevertheless the changeover and readjustment to 45° optics was intuitive and possible in a very short time. The exposure of all relevant structures within the sphenoid sinus was easily possible. Working within the sella was perfectly feasible – despite or perhaps because of 45° optics. In one of the cadaver heads even the display of the pituitary stalk and the sellar diaphragm was a success. For transsphenoidal approaches there are two important aspects. First, to keep the surgery minimally invasive within the nasal cavity and the sphenoid sinus. Second, to gain the broadest possible overview within the pituitary capsule. With the microscope alone, it is very difficult – and sometimes impossible – to view remaining tumor tissue in the recess lateral to the hypophyseal fossa. Nevertheless, with QEVO this was easily possible.

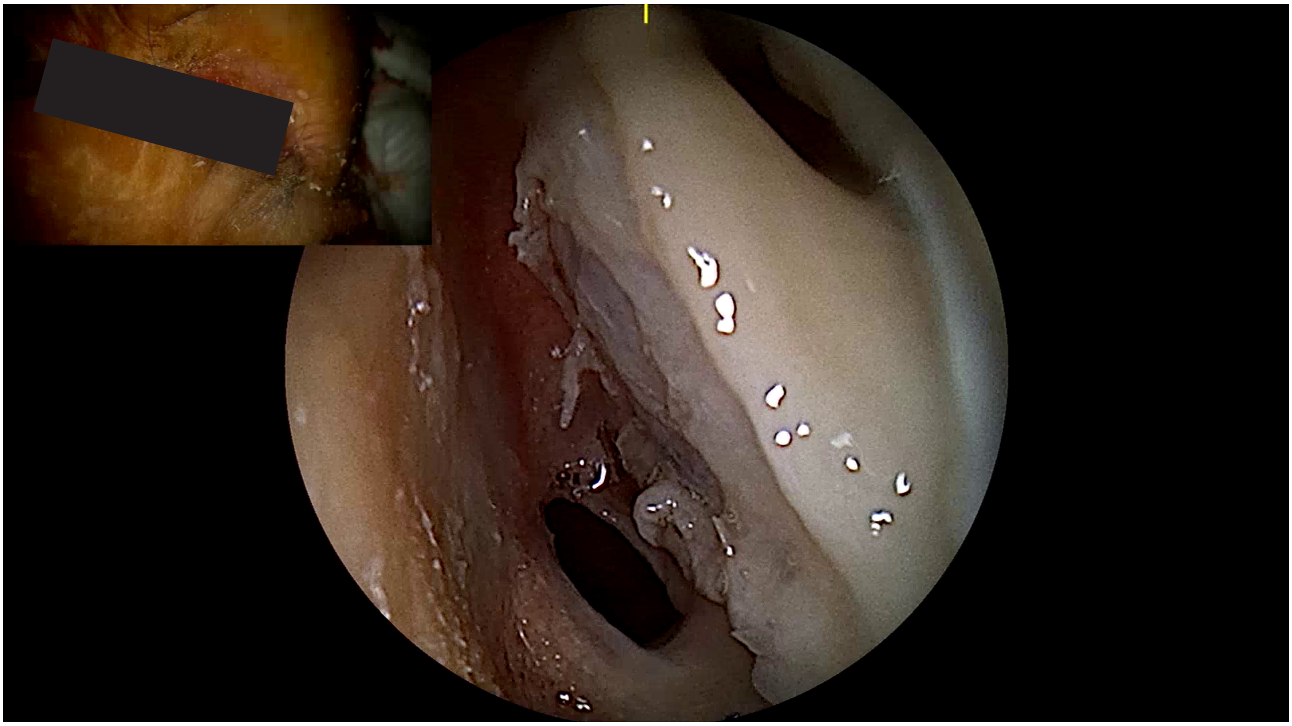

Fig. 16. View from QEVO – looking from the main nasal cavity to the ostium of the sphenoidal sinus with a simultaneous view from KINEVO 900 (top left corner picture)

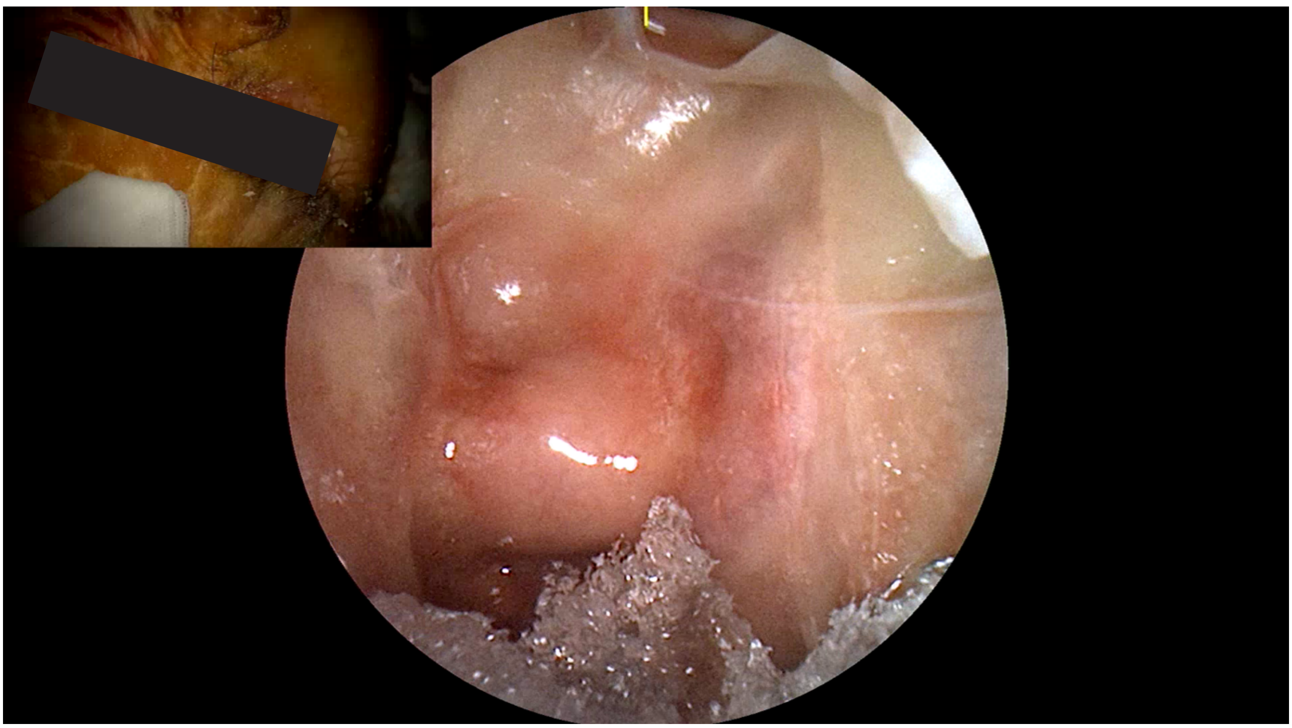

Fig. 17. View from QEVO – lateral view at the floor of the sella with a simultaneous view from KINEVO 900 (top left corner picture)

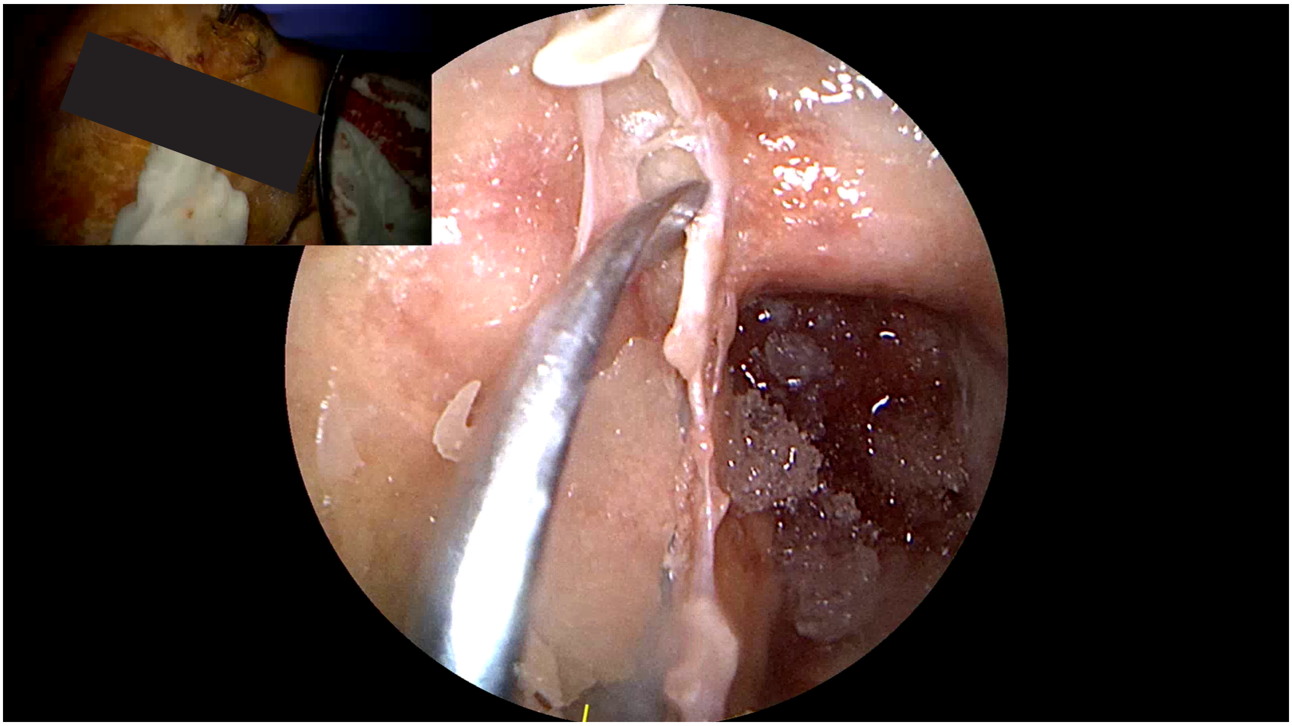

Fig. 18. View from QEVO – Dissection of the sphenoidal septum with a simultaneous view from KINEVO 900 (top left corner picture)

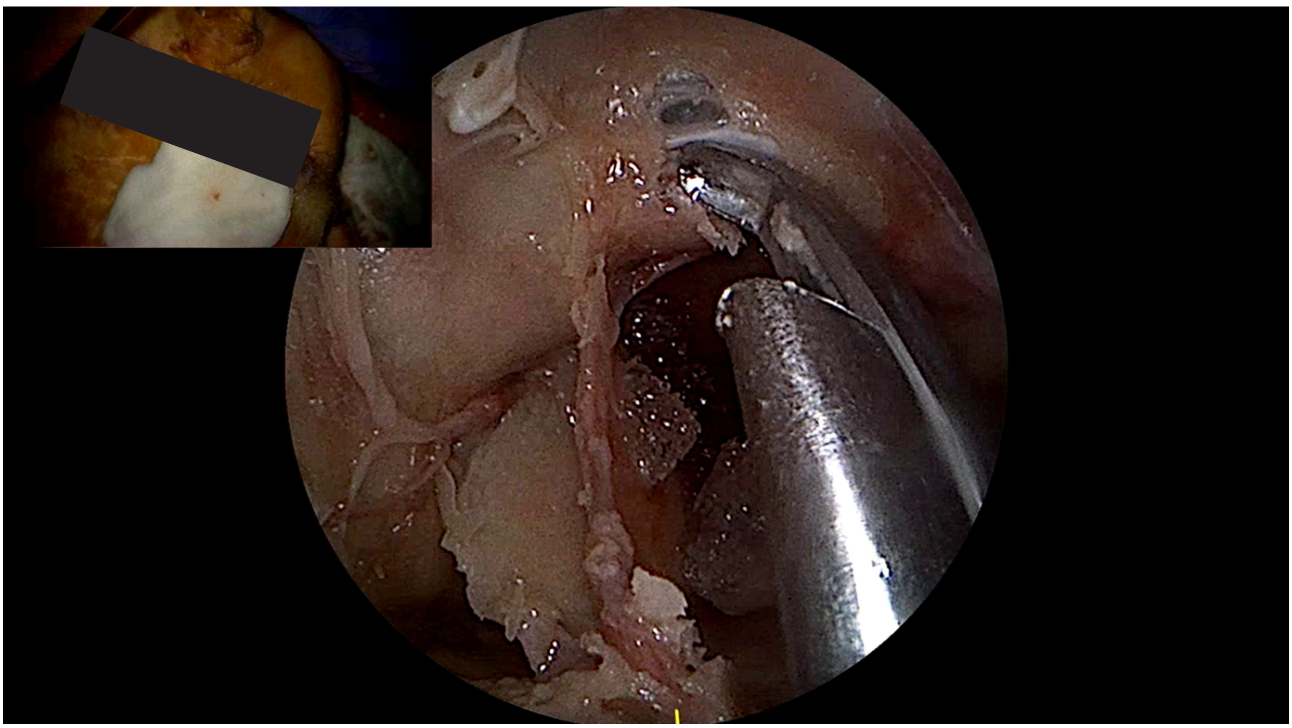

Fig. 19. View from QEVO – Trepanation of the floor of the sella with the punch with a simultaneous view from KINEVO 900 (top left corner picture)

Conclusion

The KINEVO 900 system

The application, the movement and the adjustment to the surgical field of the KINEVO is intuitive. If one looks at KINEVO 900 system as a whole, the similarity of handling compared to OPMI PENTERO 900 is striking. This applies in particular to the microscope suspension, the handgrips and the microscope head and is important for any neurosurgeon adopted to the handling of conventional surgical microscopes. The exterior design conveys an elegant impression. Both monitors are reasonably seized, have a high resolution and a good viewing angle.

The control console is operated in the usual manner. Owing to the fact that the evaluated visualization system is still a prototype, it was mainly operated by employees of ZEISS. In this respect, no final judgement can be made. Handling of the visualization system and its applications with the manual control is identical to that of the PENTERO 900. The layout of the control buttons remains identical. Switching to the QEVO picture on the monitor is done by using the pedal switch, which was readily accessible.

The implementation of the all single components, like QEVO, is easy to learn and feasible. QEVO itself has pleasant haptic properties and can be easily held for a long time. Because the neurosurgeon is used to, as a right-hander, holding the aspirator in the left hand, and also using it as a tool for dissection, it might be worthwhile to consider equipping the QEVO – if technically feasible – with an additional suction device.

Overall, our conclusion is wholly positive. The visual quality of the eyepieces and of the monitors is distinguished, the handling of the microscope and its single components is extremely user-friendly.

We would like to thank Carl Zeiss Meditec AG for the possibility of trying out this innovative tool.

Prof. Dr. med. Alexander Brawanski
Prof. Dr. med. Karl-Michael Schebesch
Dr. med. Julius Höhne

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