FULLY ENDOSCOPIC CEREBELLOPONTINE ANGLE SURGERY
A Step-By-Step Guide for Microvascular Decompression and Tumor Resection

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1.0 Introduction

Fully endoscopic surgery has quickly become a surgical standard of care in minimally invasive neurosurgery of the sella and ventral anterior skull base. The successful implementation of the endoscope in pituitary surgery has allowed many surgeons to adopt the benefits of endoscopy such as panoramic view, brilliant illumination, and faster postoperative recovery. Endoscope use in other areas of the brain such as the cerebellopontine angle (CPA), however, has been limited. At the present time, endoscopy is primarily used as an adjunct to conventional microscopic surgical techniques, so-called endoscope-assisted microsurgery (EAM). We believe that EAM is an excellent start to the use of the endoscope in the posterior fossa. However, we believe there is a natural progression from EAM to a fully endoscopic technique in the cerebellopontine angle. By starting with surgical dissection of normal anatomy through microvascular decompressions (MVD), neurosurgeons can perfect their technique and eventually become proficient with fully endoscopic tumor resection within the CPA.

We also believe that neurosurgeons should use two hands to perform microsurgery. Careful microdissection requires the use of standard techniques, such as a 5-French suction tip in the non-dominant hand and a dissector or microscissors in the dominant hand. This type of fine microdissection mandates the use of an adjustable endoscope holder. In ventral endonasal skull base surgery, an assistant such as an otolaryngologist or resident can guide the endoscope, but we believe that the CPA is a very delicate area that will not tolerate arbitrary movements, novice operating skills, or assistant’s fatigue. Hence, we believe the technique outlined in this publication provides the safest and most effective way to perform cerebellopontine angle surgery using a fully endoscopic technique.

With this publication, we offer a step-by-step operative atlas of surgical procedures within the cerebellopontine angle. A fully endoscopic procedure provides superior visualization of the neurovascular relationship allowing for successful microvascular decompression to treat cranial neuropathies such as trigeminal neuralgia, hemifacial spasm, glossopharyngeal and geniculate neuralgia. In addition, the techniques that are mastered through microvascular decompression surgery allows the surgeon to progress to resection of epidermoids, acoustic neuromas, meningiomas and brainstem cavernomas.

2.0 Traditional Microscopic MVD versus Fully Endoscopic MVD

We believe, the use of the endoscope for posterior fossa pathology will reduce complications from traditional microscopic surgery leading to improved outcomes:

- **Reduced morbidity associated with cerebellar dissection and retraction:**
  - Retraction on the cerebellum can cause direct injury to the pial surface of the brain and may lead to venous infarcts and contusions. With the endoscope, minimal retraction on the cerebellum is needed for visualization. Angled endoscopes allow for improved visualization eliminating the need to ever use a retractor.

- **Improved visualization (panorama):**
  - Neuroendoscopy allows superior panoramic visualization as compared to traditional microscope because of the proximity of the endoscope and light source to the surgical site.
  - The use of angled endoscopes also allows the neurosurgeon to see masses in locations that would otherwise be not visible with the microscope.
### 3.0 Setup and Equipment

#### Mayfield Clamp and Patient Positioning

All operations are performed under general endotracheal anesthesia. Prior to positioning the body, the patient’s head is secured in a Mayfield 3-pin head clamp. The ipsilateral side of the pain is the forehead in which the single pin is placed. This pin is positioned medial to the ipsilateral lateral canthus and at least 2 cm above the eyebrow to avoid damage to the supraorbital nerve. The posterior two pins are placed above the occipital muscles and below the superior temporal line to ensure the clamp will not slip. The patient is then turned in a full lateral position with an axillary role placed slightly caudal to the axilla so that the axilla will be pressure-free. The patient is taped down securely with generous amounts of wide three-inch cloth tape. A bean bag is not used. The head is flexed approximately two finger breadths from the sternum and rotated 70–80 degrees away from the side of the operation. The goal is to keep the vertex of the head parallel to the floor so that the cranial nerve VII–VIII bundle is more inferior than the trigeminal nerve. After positioning, the Mayfield clamp is tightened to 60 pounds of pressure and secured.

Shaving approximately 2 – 3 cm behind the ear is sufficient. The following landmarks should be noted prior to prepping: the tip of the mastoid process (Figs. 1, 2), the zygomatic arch, and the inion. The course of the transverse sinus can be estimated by drawing a line from the inion to the zygomatic arch. An oblique line drawn on the posterior border of the mastoid process approximates the course of the sigmoid sinus. The postero-inferior quadrant of the intersection of these two lines is where the burr hole should be placed. Although we do not currently use frameless navigation for posterior fossa, extra-axial retrosigmoid cranial surgery, we do believe that the use of navigation would allow the surgeon to minimize the incision even more by allowing for direct placement at the sigmoid-transverse sinus junction.

For CPA tumor resection, the straight linear incision from microvascular decompression surgery is lengthened and superior and inferior curves are added to create a sigmoid-shaped incision (Fig. 3).
Mitaka Point Setter Pneumatic Holding System

The authors use a dedicated system* that consists of a pneumatically driven powered holding arm, a micromanipulator, and an endoscope adaptor (Figs. 4–7). To release the joints, the pneumatic arm uses pressurized nitrogen available in most operating rooms. As a built-in safety feature, in case the gas cord is inadvertently disconnected, the pneumatic arm remains stationary and can only be released if the gas tubing is reattached. The Mitaka Point Setter is firmly secured at the most cephalad aspect of the patient’s bed. One of the benefits of a bed-mounted endoscope holder is that if the bed is moved to optimize patient positioning for surgeon comfort, the relative position of the joints remains fixed. This is different from the floor-mounted Mitaka pneumatic arm available. The joints are then arranged in a “figure-of-four” (Figs. 4–7). After some trial and error, we have found that this arrangement allows for maximum flexibility of endoscope position during surgical procedures.

* (Mitaka Kohki Co. Ltd., Tokyo, Japan; sold and distributed by KARL STORZ Tuttlingen, Germany)
The pneumatic arm allows for quick adjustment of the endoscope position, however, it is only balanced for its own weight. Additional coupling of endoscope and camera results in “sag” which requires careful compensation during surgery. Some surgeons may choose to use the micromanipulator with the Mitaka arm. In early stages of our work, the micromanipulator was primarily used to drive the endoscope superficial and deep. The lateral and anterior/posterior movements were not utilized (Fig. 8). With the micromanipulator attached to the end of the arm, the last ball-joint (distal ball-joint) should be placed directly over the proposed burr hole site (Fig. 9). Without the micromanipulator, the second ball-joint should be placed over the burr hole site (Fig. 10). This length allows for sufficient working distance during the operation and eliminates the need to loosen the twist joints (Fig. 7) during the procedure. Early in our experience, we found the micromanipulator useful for fine adjustment, however, we currently do not use it. The micromanipulator allows an extra degree of safety when moving instruments in and out of field. If the instrument cannot be seen because the tip of the instrument has not yet reached the surgical field, the surgical assistant can drive the scope up and down depending on where the instruments are located.
Duraprene™ Patties and Teflon

In order to decrease friction and trauma to the cerebellar pial surfaces, Dr. Jannetta described placing non-traumatic material on the underside of surgical patties. This is accomplished by using Duraprene™ gloves cut to the size of surgical patties. Once moistened, these two materials will attach together and can then be placed along the pial surface when retracting on the cerebellum. Figure 11 shows small shreds of Teflon that have been rolled together to make a tight pad used in microvascular decompression of cranial neuropathies.

Operating Room Setup

Ensure that the patient, micromanipulator arm and endoscopic tower are all in direct view during surgery (Figs. 12-15). Note the position of the Mitaka holding arm looped over the patient from the opposite side of the operating surgeon. Also note the use of the offset endoscope with hand positions as shown.
4.0 Surgical Procedure for Microvascular Decompression

For sterile technique prepping, we use Steris Bactoshield CHG 4% and chlorhexidine gluconate 4%. General endotracheal anesthesia is performed. The patient is hyperventilated to obtain hypocapnia and a half-dose of 20% mannitol is used to aid in relaxing the cerebellum for retraction during surgery. The skin incision is linear approximately 5 cm long, just inferior to the junction of the transverse and sigmoid sinuses and approximately one centimeter behind the patient’s hair line. The digastric groove, which is the insertion of the posterior belly of the digastrics, is identified as a landmark (Fig. 16). The burr hole for the craniotomy is centered slightly posterior to the superior portion of the digastic muscle insertion. This designates the approximate junction of the transverse and sigmoid sinuses. A burr hole is made and expanded with a cutting burr (Figs. 17, 18). Bone wax is used to fill the mastoid air cells to prevent cerebrospinal fluid (CSF) rhinorrhea or otorrhea.
Dural Opening

An approximately 8 mm C- or U-shaped incision is made in the dura mater and suspended by a stitch anteriorly against the sigmoid sinus (Fig. 19). Following creation of a dural opening, the endoscope is brought in. The general rule for placement of the endoscope, suction and microinstruments is to create a triangle in the 12 (A), 5 (B), and 7 (C) o’clock positions (Fig. 19) to minimize sword clash. Specifically, the endoscope is kept at the apex of the triangle (12 o’clock), Fukushima variable control suction (7 o’clock) is used in the left hand, microinstruments (5 o’clock) in the right hand (Figs. 21, 22).

SEPEHRNIA instruments (KARL STORZ Tuttlingen, Germany) are preferred for the majority of CPA manipulation because they allow for opening without getting into conflict with the endoscope. For bipolar cautery, conventional microbipolars are useful for the early stages of dissection, but as the dissection progresses deeper, the KARL STORZ take-apart endoscopic bipolar forceps are used. This is due to the fact that conventional bipolars will often not open in the confined space provided by this particular approach, thus making the KARL STORZ take-apart bipolar forceps necessary because it is designed to open only at the tip of the instrument. In order to maximize working space, we prefer to use the 0°-endoscope, 2.7 mm in outer diameter. Other authors have described using the 4-mm scope, which as compared to the 2.7-mm scope, has a higher level of resolution. This is partially offset by the ability to perform a true optical zoom with the KARL STORZ HD camera. We have found the 2.7-mm scope to be the best compromise between quality and access. For larger tumor resections where the dural opening can be significantly larger, the 4-mm scope is used.
Endoscopic Microvascular Decompression

The Duraprene™ patty combination is placed in an antero-inferior direction in order to prevent trauma to the pial surface of the cerebellum. Retractors are never used to displace the cerebellum, as we believe that retraction results in unnecessary trauma to the cerebellum for most procedures in the posterior fossa. The endoscope is guided along the path of the petrous dura with minimal retraction on the cerebellum. The petrous dura represents the “12 o’clock” position for instrument placement in the tight confines of the cerebellopontine angle. The arachnoid sheath around the cranial nerve IX, X, XI bundle is dissected with SEPEHRNIA microscissors (Figs. 23, 24). Slow drainage of CSF allows visualization of the cranial nerve IX, X, XI complex in the CPA.

Note the use of the SEPEHRNIA microscissors with the angled blades turned to the right for this right-sided microvascular decompression (Fig. 26). For right-handed surgeons, the right curved SEPEHRNIA scissors are best. For left-handed surgeons, the left curved SEPEHRNIA scissors can be used. The left hand controls a straight microsuction 5 French with Fukushima variable tip control.

Note, that the endoscope is placed close enough to the field in order to see the target anatomy, but not so close that triangulation of instruments is compromised. In addition, by keeping the endoscope far from target, this provides a panoramic view which allows for early identification of instruments as they are introduced into the field.

There is often a bridging vein either above or below the lower cranial nerves (IX, X, XI) that may tear upon initial dissection of the cerebellomedullary cistern. Special care must be taken to gently open the cistern and identify this vein if necessary (Fig. 26). SEPEHRNIA microscissors are used to cut the arachnoid as needed.

Also note, that with the use of the Mitaka Point Setter endoscope holder, all microdissection is performed with two hands using a conventional but modified microsurgical technique.
Using a combination of bipolar coagulation of minor vessels and blunt dissection, the arachnoid around the trigeminal nerve is lysed and the vascular anatomy around the trigeminal nerve can be inspected. Arachnoid has been cut from lower cranial nerves to above CN VII and VIII (Fig. 27).

The CPA can be divided anatomically through the endoscope into two zones separated by the acousticofacial bundle. In this surgical atlas, we describe cranial neuropathies in both the superior zone above the acousticofacial bundle where the trigeminal nerve and Meckel’s cave can be explored and the inferior zone that gives rise to the glossopharyngeal and vagus nerves.

5.0 Illustrative Cranial Neuropathies

Trigeminal Neuralgia – SCA Compression

Case 1

This is a left-sided microvascular decompression of trigeminal neuralgia. This is an example of classic vascular compression by the superior cerebellar artery (SCA) resulting in lateral and inferior deformation of the trigeminal nerve (Figs. 28, 29). The Dandy petrosal vein is not sacrificed in the great majority of fully endoscopic procedures, since the panoramic view of the endoscope allows the vein to be visualized throughout the procedure. The degree of stretch on the vein can be monitored at all times. In addition, to avoid the formation of future Teflon granulomas, the authors prefer to keep the arachnoid cephalad to the trigeminal nerve intact if possible. Notice the improvement in the coloration of the nerve after the Teflon is placed in between the trigeminal nerve and the superior cerebellar artery (Fig. 30).
Case 2

This is a left-sided microvascular decompression for trigeminal neuralgia (Figs. 31, 32). In this case, the superior cerebellar artery compresses the medial/inferior side of the trigeminal nerve (Figs. 33–35). There are surrounding petrosal veins, but they are not in vascular contact with the trigeminal nerve. Microvascular decompression is achieved by placing a Teflon pad between the offending vessel and the trigeminal nerve so that the Teflon pushes away the vessel from the nerve (Fig. 36). The Teflon pad can be adjusted with microinstruments.
Trigeminal Neuralgia – AICA Compression

**Case 3**

This is a right-sided microvascular decompression for trigeminal neuralgia (Figs. 37, 38). It is often better to keep the VIIth and VIIIth nerve complex in view of the endoscopic panorama rather than placing the endoscope tip past the VIIth and VIIIth nerve complex. This makes for much safer entry of instruments into the field.

In this case, the vascular compression is easily identified. The Vth nerve is deformed from the caudal side by a branch of the anterior inferior cerebellar artery. A single piece of Teflon is placed between the trigeminal nerve and AICA.

Trigeminal Neuralgia – Venous Compression

**Case 4**

This is a right-sided microvascular decompression for trigeminal neuralgia (Figs. 39–41). One of the benefits of the angled endoscope is that it can help the surgeon appreciate anatomy that is not visible with a microscope. In this case, the 0°-scope provides only a straight ahead view of the trigeminal nerve at the root entry zone. With the use of the scope, the nerve is inspected and no artery is identified on the cephalad and medial side (not shown). Hence, a 30° up-angled scope is used to carefully delineate the petrosal vein crossing the distal aspect of the trigeminal nerve (Figs. 39–41). With the 0°-scope, the separation of the nerve from the vein is not well appreciated. Introducing the 30°-scope, however, allows for a better appreciation of the separation and allows for placement of Teflon between the two (Figs. 39, 40).
Although the classic teaching is that the compression is near the brainstem at the Obersteiner-Redlich zone, the 30°-scope has increasingly demonstrated the importance of venous anatomy near the entrance to Meckel’s cave more distally along the nerve.

Shown in Figs. 41–43 is the 30° lateral view of the final decompression and the VII\textsuperscript{th} and VIII\textsuperscript{th} nerve complex. Notice the petrous tubercle, sometimes called the suprameatal petrous bone, which occasionally can be quite prominent (Fig. 43). With microscopes only, visualization sometimes required removal of the petrous tubercle. With endoscopes, however, visualization is solved by placing the endoscope past the tubercle, and wonderful views can be obtained (Figs. 41–42). The use of 30°-scopes improves this even further. Improved ability to dissect will require introduction of new instruments with appropriate angled bends.
Hemifacial Spasm

Case 5

This is a right-sided microvascular decompression for hemifacial spasm. In conventional microscopic microvascular decompression procedures for hemifacial spasm, a retractor is often necessary to visualize the root entry zone of the seventh nerve. The use of endoscopes, however, can eliminate the need for a retractor because of its wide angle view. In this case, the 0°-scope can provide a beautiful view of the root entry zone of the VIIth nerve as well as the VIIIth and IXth nerve and lower pontine brainstem. This often results in a reflection of petrous dura as seen here in the top of the field. The surgery can be successfully performed with a 0°-scope as seen in this example (Figs. 44–46).
**Case 6**

This is a left-sided microvascular decompression for hemifacial spasm. The 0°-scope provides the usual views of the posterior fossa anatomy (Figs. 47, 48). The petrous dura is in the top of the field as is typical for views of the brainstem for microvascular decompression of cranial nerve VII. In this case, an angled scope is very useful.

The 30° line of sight, angled downward, has proven to be beneficial in the treatment of hemifacial spasm and geniculate neuralgia (Figs. 49, 50). Notice the different perspective compared to the aforementioned figures, which were taken with the 0°-scope. Indeed, the tremendous benefit of the 30°-scope lies in the fact that it gives the option to avoid any cerebellar retraction whatsoever in order to find the VIIth nerve at the root entry zone. With traditional microscopic MVD surgery for hemifacial spasm, the surgeon must generally retract at the flocculus of the cerebellum to see the root entry zone, but with an angled scope, no retraction is necessary at all.
Case 7

This is the case of a right-sided microvascular decompression for hemifacial spasm. The 30°-scope is absolutely critical here to visualize the root entry zone without any retraction of the cerebellum.

Fig. 50 demonstrates a beautiful view of the ventral pons with the root entry zone of the VIIth nerve seen in the lower left-hand corner. Its usual greyish appearance stands in clear contrast to the ventral pons. The 30°-scope has been advanced between the VIIIth and IXth cranial nerves, and hence these nerves are no longer visible. Microdissection with this type of view must be carefully performed, because the suction tip or other instruments are not visible until past the VIIIth and IXth cranial nerves. The authors recommend hugging the shaft of the scope when introducing instruments. The AICA loop is compressing the root entry zone of the VIIth nerve and needs to be elevated without tearing any perforators to the brainstem. Cranial nerve VI can be seen in the distance. Fig. 52 demonstrates the technique for gently elevating the AICA branch while Fig. 53 shows the placement of Teflon using the SEPEHRNIA cupped forceps.
Glossopharyngeal Neuralgia

Case 8

This is a left-sided microvascular decompression of cranial nerve IX. In this case, an angled scope was not necessary. The 0° view provides excellent depiction of vertebral artery compression of the IXth nerve. The artery can be mobilized and a piece of Teflon is placed (Figs. 54–59).
Geniculate Neuralgia

Case 9

The geniculate nerve can be very difficult to find. With a microscope, the classic maneuver is to gently retract the flocculus below the VIIIth nerve near the IXth nerve and to search for a distinct nerve. However, a 30°-scope faced medially eliminates the need for a retractor.

Shown below are endoscopic still images taken with a 30°-scope, angled downward. The perspective on the brainstem is phenomenal and impossible without more dramatic retraction when using a microscope. Here, you can see the sectioning of nervus intermedius.

Fig. 60 is a 0° view allowing visualization of the VIIth nerve, but not of the nervus intermedius. Use of the 30°-scope, angled downward, allows much better appreciation of the anatomy and identification of the nervus intermedius (Figs. 61–62).
Tumors – Extended Retrosigmoid Craniotomy

Epidermoid

Case 10

This is the case of a 19-year-old college freshman who presented with headaches. The patient has a right epidermoid cyst. These are among the best cases in which to start the progression to fully endoscopic neurosurgery of the posterior fossa in the cerebellopontine angle. This procedure was performed with the 2.7-mm scopes; however, given the larger size of the craniotomy, this procedure could have been performed with a 4-mm scope. In the authors’ experience, the larger-diameter 4-mm scope does provide a larger picture and better resolution (Figs. 63–75).
Case 11

This is the case of a 50-year-old woman, who presented with dramatic growth of this meningioma over a period of five years. Given the growth, the patient preferred surgical resection to stereotactic radiosurgery. She did not have any significant hearing loss, vertigo, imbalance, ataxia or facial symptoms. This procedure was performed as a purely endoscopic retrosigmoid resection using the 2.7-mm scopes. When a larger craniotomy is performed, standard bipolars and standard microsurgical techniques can be employed (Figs. 76–86).
Vascular Malformations

Pontine Cavernoma

Case 12

This 60-year-old patient presented with acute onset of left-sided facial paralysis (HB grade 5/6) and hearing loss. Imaging revealed left pontine cavernous malformation. Postoperatively, her facial paralysis progressed to House Brackmann grade 6/6 and her hearing did not improve. However, no additional deficits were incurred, and the cavernoma was removed completely (Figs. 87–93).
Midbrain Cavernoma

Case 13

This is the case of a 35-year-old patient with acute onset of right hemibody numbness and loss of both pain and temperature as well as light touch. After initial observation in the hospital, the patient hemorrhaged again with worsening of headache and hemibody numbness. A supracerebellar infratentorial approach was taken to remove the cavernoma.

A retrosigmoid approach was taken first in order to drain CSF from the cerebellomedullary cistern. After the cerebellum became slack, the approach was changed to infratentorial supracerebellar (Figs. 95–97).
Closure

After the procedure is completed, whether it is a microvascular decompression or tumor/cavernoma resection, we then stop any active bleeding using a combination of bipolar coagulation, Floseal®, Surgicel® and/or Gelfoam®. We inject warmed physiological saline into the CPA in order to compensate for the loss of CSF during the operation. The dura mater is meticulously sutured using 4-0 silk Nurolon® sutures and can be supplemented with local muscle autograft in order to achieve a water-tight closure. A small piece of Medtronic DuraRepair® or Integra Duragen® is placed over the cranio tomy defect. We place a small piece of gelfoam (Johnson and Johnson Inc., New Brunswick, NJ, USA) in order to recapitulate the cancellous bone depth that was removed during the craniectomy. For microvascular decompression cases, since the endoscope allows for a minimally invasive opening, the bone removal can be minimal. In this case, we place one round burr hole cover to protect the cranio tomy defect (Fig. 100).

The muscle and galea aponeurosis layer are approximated and closed with vicryl sutures and the skin layer is closed with a running nylon suture.

6.0 Results and Complications

In abstract format, we have published our work comparing patients each with purely microvascular decompression and purely endoscopic microvascular decompression (North American Skull Base Society, NASBS 2012). In addition, a similarly step-wise approach on this topic has been published in ORL, 2012 Dec 12;74(6). In our abstract, we presented results on two groups. The two groups represent a convenience sample, and thus their preoperative characteristics were not balanced. 90% of the patients undergoing MVD had type one Burchiel trigeminal neuralgia, whereas only 44% of the E-MVD group had type one Burchiel trigeminal neuralgia. In addition, symptom duration prior to surgical intervention was 4 years in the MVD group versus 6 years in the E-MVD group. Despite the lack of balance between the two groups, we observed that patients who underwent microvascular decompression self-reported statistically significant improvements in their Brief Pain Index (BPI)-Facial scores. The mean change in numerical rating scale pain from preoperative to postoperative condition was not statistically different between the microscopy group and the purely endoscopic group. We plan to follow outcomes in a serial manner over time. Preliminary (< 3 year results) have not demonstrated any significant difference in outcomes between microscopic versus endoscopic surgical procedures. We did find a learning curve in procedure length. Purely microscopic cases required 120 minutes. The first five endoscopic cases required 160 minutes on average, but the last series of purely endoscopic cases required the same 120 minutes as the microscopic cases. There was no significant difference in complications.
7.0 Comments and Nuances

There are several important points about endoscopy and keyhole surgery in the posterior fossa. The skilled neurosurgeon must learn to work around the endoscope, often using techniques that have been borrowed from endonasal ventral skull base surgery. Just like endonasal skull base surgery, instruments are introduced in a path parallel to the shaft of the endoscope. Hence, instruments curved gently at the tip are the most useful, such as the SEPEHRNIA microscissors. We have not found larger curves to be useful as it can become dangerous near multiple delicate vessels and nerves to use more aggressively curved instruments. Some tricks that aid beginning surgeons include hugging the shaft of the endoscope as instruments are introduced in order to predict the position of the tool upon entry. Another useful trick is to use the micromanipulator early in one's learning curve. In this way, the endoscope can be parked higher in the cerebellopontine angle and then gradually advanced closer to target by the assistance. In this way, introduction of instruments (suction and dissector/scissors/bipolar) can be performed more safely.

The use of the pneumatic endoscope holder (Mitaka Kohki Co.) is quite valuable for this work. In contrast to endonasal endoscopic surgery, delicate movements from the very start. In endonasal surgery, delicate movements are only employed after the dura is opened. In cerebellopontine angle endoscopic surgery, delicate fine microsurgery is introduced at the very beginning of the case, and thus we believe that the use of an endoscope holder is paramount. If the assistant accidentally jostles the endoscope in the endonasal corridor, the assistant will hit a turbinade or a cartilaginous septum. In contrast, if the assistant holds the endoscope during cerebellopontine angle surgery, the assistant will hit the VIIth/VIIIth nerve complex causing possible irreversible damage. Hence, we strongly advocate the use of an endoscope holder.

Endoscopes of various viewing angles are extremely useful during surgery. We have found the 30°-scope to be the best compromise of maneuverability and improved visualization. When using the 30°-scope, the triangle concept of instrument placement continues to be useful for maximizing maneuverability. We have found the 30°-scope to be the most useful to identify the anatomy between the VIIth and IXth cranial nerves, especially for hemifacial spasm and identification of the nervus intermedius for geniculate neuralgia.

Endoscopic approaches to the posterior fossa represent a natural evolution in endoscopic surgery of the skull base. A gradual progression from the microscope to a fully endoscopic procedure starts with microvascular decompression then to benign tumors (meningiomas and acoustic neuromas) and then to vascular lesions such as cavernomas. We believe endoscopic approaches through the posterior fossa can in the future be expanded to supracerebellar transtentorial resections of medial temporal lobe lesions as well as expanded retrosigmoid suprameatal approaches to trigeminal schwannomas. In addition, a supracerebellar transtentorial route may provide an extra-axial approach to perform an amygdalo-hippocampectomy for seizure surgery in the future. Although we assume that endoscopic instrumentation will continue to evolve, we strongly believe that once the problem of visualization of pathology is resolved, the surgeon will innovate new ways to operate on it. The endoscope provides the light and visualization, and we surgeons will provide the innovation!

8.0 Selected Publications

Instruments, Units and Video Equipment for
Fully Endoscopic Cerebellopontine
HOPKINS® Telescopes
Diameter 2.7 mm, length 15 cm

28162 AUA  HOPKINS® Straight Forward Telescope 0°,
diameter 2.7 mm, length 15 cm, autoclavable,
proximally angled eyepiece and light connection,
fiber optic light transmission incorporated,
color code: green

28162 BUA  HOPKINS® Forward-Oblique Telescope 30°,
enlarged view, diameter 2.7 mm, length 15 cm,
direction of view in 6 o’clock position, autoclavable,
proximally angled eyepiece and light connection,
fiber optic light transmission incorporated,
color code: red

28162 BOA  HOPKINS® Forward-Oblique Telescope 30°,
enlarged view, diameter 2.7 mm, length 15 cm,
direction of view in 12 o’clock position, autoclavable,
proximally angled eyepiece and light connection,
fiber optic light transmission incorporated,
color code: red

Diameter 4 mm, length 20 cm

28162 AVA  HOPKINS® Straight Forward Telescope 0°,
enlarged view, diameter 4 mm, length 20 cm,
autoclavable, with angled eyepiece,
fiber optic light connection incorporated,
color code: green

28162 BVA  HOPKINS® Forward-Oblique Telescope 30°,
enlarged view, diameter 4 mm, length 20 cm,
autoclavable, with angled eyepiece,
fiber optic light connection incorporated,
color code: red

It is recommended to check the suitability of the product for the intended procedure prior to use.
SEPEHRNIA Neurosurgical Micro Instruments

Needle Holder and Forceps

28164 NBB  Micro Needle Holder, bayonet shaped, 2 x 6 mm, jaw straight, working length 10 cm

28164 NBC  Micro Needle Holder, bayonet shaped, 1 x 6 mm, jaw curved to left, working length 10 cm

28164 PBA  Micro Grasping Forceps, bayonet-shaped, 0.5 mm, smooth, working length 10 cm

28164 PBC  Micro Forceps, bayonet shaped, serrated, 3 mm, jaws straight, working length 10 cm

28164 PBD  Micro Forceps, bayonet shaped, 0.75 mm, jaws curved to left, working length 10 cm
SEPEHRNIA Neurosurgical Micro Instruments

**Forceps**

28164 PBB  **Micro Forceps**, bayonet-shaped, 2 mm spoon, working length 10 cm

28164 PBE  **Micro Forceps**, bayonet shaped, 4 mm, spoon, working length 10 cm

28164 PBG  **Micro Forceps**, bayonet shaped, 2 mm, spoon horizontal, working length 10 cm

28164 PBH  **Micro Forceps**, bayonet shaped, 4 mm, spoon horizontal, working length 10 cm
SEPEHRNIA Neurosurgical Micro Instruments

Scissors and Applying Forceps

28164 SBA  **Micro Scissors**, horizontal, bayonet-shaped, sharp/sharp, straight, working length 10 cm

28164 SBB  **Micro Scissors**, bayonet-shaped, sharp/sharp, left curved, working length 10 cm

28164 SBC  **Micro Scissors**, bayonet shaped, blunt/blunt, jaw straight, working length 10 cm

28164 SBD  **Micro Scissors**, bayonet shaped, sharp/sharp, jaw curved to right, working length 10 cm

28164 SBE  **Micro Scissors**, bayonet shaped, sharp/sharp, jaws horizontal, working length 10 cm
Dissectors
Working length 10 and 13 cm

28164 DKA

28164 DKA **Dissector**, tip angled 15°, width 1 mm, working length 10 cm
28164 DLA **Same**, working length 13 cm

28164 DKB **Dissector**, tip angled 45°, width 1 mm, working length 10 cm
28164 DLB **Same**, working length 13 cm

28164 DKC **Dissector**, tip angled 90°, width 1 mm, working length 10 cm
28164 DLC **Same**, working length 13 cm

28164 DKD **Dissector**, tip angled 15°, width 0.5 mm, working length 10 cm
28164 DLD **Same**, working length 13 cm

28164 DKE **Dissector**, tip angled 45°, width 0.5 mm, working length 10 cm
28164 DLE **Same**, working length 13 cm

28164 DKF **Dissector**, tip angled 90°, width 0.5 mm, working length 10 cm
28164 DLF **Same**, working length 13 cm
Circular Knives
Working length 10 and 13 cm

28164 TKA  Circular Knife, straight, width 1 mm, working length 10 cm
28164 TLA  Same, working length 13 cm

28164 TKB  Circular Knife, 45° curved upwards, width 1 mm, working length 10 cm
28164 TLB  Same, working length 13 cm

28164 TKC  Circular Knife, 90° curved upwards, width 1 mm, working length 10 cm
28164 TLC  Same, working length 13 cm

28164 TKD  Circular Knife, straight, size 2 mm, working length 10 cm
28164 TLD  Same, working length 13 cm

28164 TKE  Circular Knife, 45° curved upwards, size 2 mm, working length 10 cm
28164 TLE  Same, working length 13 cm

28164 TKF  Circular Knife, 90° curved upwards, size 2 mm, working length 10 cm
28164 TLF  Same, working length 13 cm
Suction Tubes
Working length 15 cm

649179 B  Suction Tube, malleable, with elongated cut-off hole and stylet, Luer, 4 Fr., working length 15 cm

649180 B  Suction Tube, malleable, with conical tip, with elongated cut-off hole and stylet, Luer, 6 Fr., working length 15 cm

649182 B  Suction Tube, malleable, with conical tip, with elongated cut-off hole and stylet, Luer, 8 Fr., working length 15 cm

649183 B  Suction Tube, malleable, with conical tip, with elongated cut-off hole and stylet, Luer, 10 Fr., working length 15 cm
**TAKE-APART** Bipolar Forceps
Outer diameter 3.4 mm, working length 14 cm

28164 BDC  **TAKE-APART** Bipolar Forceps,
short, width 2 mm, outer diameter 3.4 mm,
working length 14 cm,
including:
- Handle
- Outer Sheath
- Inner Sheath
- Bipolar Insert

28164 BDB  **TAKE-APART** Bipolar Forceps,
short, width 2 mm, outer diameter 3.4 mm,
rounded tip, working length 14 cm,
including:
- Handle
- Outer Sheath
- Inner Sheath
- Forceps Insert
TAKE-APART® Bipolar Forceps
Outer diameter 3.4 mm, working length 20 cm

28164 BDL

TAKE-APART® Bipolar Forceps,
width 1 mm, delicate jaws, distally angled 45°,
vertical closing, outer diameter 3.4 mm,
working length 20 cm,
including:
Handle
Outer Tube
Inner Tube
Bipolar Insert
Bipolar Coagulating Forceps
for use with Bipolar High Frequency Cords 847000 or 847000 A/E/M/V

28164 BPA  Bipolar Coagulating Forceps, insulated, bayonet-shaped, blunt, tip 0.7 mm, working length 12 cm, total length 23 cm

28164 BPB  Same, working length 14 cm, total length 25 cm

28164 BPC  Same, tip 0.3 mm

Accessories
High Frequency Cords, for use with Bipolar Coagulation Instruments

Bipolar High Frequency Cords

<table>
<thead>
<tr>
<th>KARL STORZ Instruments</th>
<th>High Frequency Electrosurgery Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>847000 E</td>
<td>Bipolar High Frequency Cord, to KARL STORZ Coagulator 26021 B/C/D, 860021 B/C/D, 27810 B/C/D, 28810 B/C/D, AUTOCON® system (50, 200, 350), AUTOCON® II 400 system (111, 113, 115) and Erbe-Coagulator, T- and ICC-row, length 300 cm</td>
</tr>
<tr>
<td>847000</td>
<td>Bipolar High Frequency Cord, with 2x 4 mm banana plug to KARL STORZ Coagulator 26020 XA/XB for KARL STORZ bipolar coagulation forceps, length 300 cm</td>
</tr>
<tr>
<td>847000 A</td>
<td>Bipolar High Frequency Cord, with 2x 4 mm banana plug for KARL STORZ Coagulator 26020 XA/XB and Valleylab, length 300 cm</td>
</tr>
<tr>
<td>847000 M</td>
<td>Bipolar High Frequency Cord, for Martin and Berchtold coagulators, length 300 cm</td>
</tr>
<tr>
<td>847000 V</td>
<td>Bipolar High Frequency Cord, for KARL STORZ AUTOCON® II 400 system (112, 114, 116), Valleylab coagulator, length 300 cm</td>
</tr>
</tbody>
</table>
POINT SETTER® Holding System

28163 WS POINT SETTER®, pneumatic holding arm
including:
POINT SETTER® Holding Arm, with OR table adaptor
KSLOCK Adaptor, for clamping jaws
Clamping Jaw, large
Clamping Jaw, small
Clamping Jaw, for fiberscopes
Pressure Regulator, 7 bar
Drape, for single use, sterile, package of 10

28172 WD Drape, for single use, sterile, package of 10

Note: Compressed air tubing is required to operate the POINT SETTER® arm.
IMAGE1 S Camera System  

Economical and future-proof
- Modular concept for flexible, rigid and 3D endoscopy as well as new technologies
- Forward and backward compatibility with video endoscopes and FULL HD camera heads
- Sustainable investment
- Compatible with all light sources

Innovative Design
- Dashboard: Complete overview with intuitive menu guidance
- Live menu: User-friendly and customizable
- Intelligent icons: Graphic representation changes when settings of connected devices or the entire system are adjusted
- Automatic light source control
- Side-by-side view: Parallel display of standard image and the Visualization mode
- Multiple source control: IMAGE1 S allows the simultaneous display, processing and documentation of image information from two connected image sources, e.g., for hybrid operations

Dashboard
Live menu
Intelligent icons
Side-by-side view: Parallel display of standard image and Visualization mode
Full HD image

Brilliant Imaging
- Clear and razor-sharp endoscopic images in FULL HD
- Natural color rendition

- Reflection is minimized
- Multiple IMAGE1 S technologies for homogeneous illumination, contrast enhancement and color shifting

FULL HD image

CLARA

FULL HD image

CHROMA

FULL HD image

SPECTRA A*

FULL HD image

SPECTRA B**

* SPECTRA A: Not for sale in the U.S.
** SPECTRA B: Not for sale in the U.S.
**IMAGE1 S Camera System**

**TC 200EN**

**TC 200EN**

**IMAGE1 S CONNECT**, connect module, for use with up to 3 link modules, resolution 1920 x 1080 pixels, with integrated KARL STORZ-SCB and digital Image Processing Module, power supply 100–120 VAC/200–240 VAC, 50/60 Hz including:

- **Mains Cord**, length 300 cm
- **DVI-D Connecting Cable**, length 300 cm
- **SCB Connecting Cable**, length 100 cm
- **USB Flash Drive**, 32 GB, USB silicone keyboard, with touchpad, US

*Available in the following languages*: DE, ES, FR, IT, PT, RU

**Specifications:**

- HD video outputs: 2x DVI-D, 1x 3G-SDI
- Format signal outputs: 1920 x 1080p, 50/60 Hz
- LINK video inputs: 3x 4x USB, (2x front, 2x rear) 2x 6-pin mini-DIN
- USB interface: 4x USB, 6-pin mini-DIN
- SCB interface: 2x 6-pin mini-DIN
- Power supply: 100–120 VAC/200–240 VAC
- Power frequency: 50/60 Hz
- Protection class: I, CF-Defib
- Dimensions w x h x d: 305 x 54 x 320 mm
- Weight: 2.1 kg

**TC 300**

**TC 300**

**IMAGE1 S H3-LINK**, link module, for use with IMAGE1 FULL HD three-chip camera heads, power supply 100–120 VAC/200–240 VAC, 50/60 Hz, for use with **IMAGE1 S CONNECT TC 200EN** including:

- **Mains Cord**, length 300 cm
- **Link Cable**, length 20 cm

**Specifications:**

<table>
<thead>
<tr>
<th>Camera System</th>
<th>TC 300 (H3-Link)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supported camera heads/video endoscopes</td>
<td>TH 100, TH 101, TH 102, TH 103, TH 104, TH 106 (fully compatible with IMAGE1 S) 22220055-3, 22220056-3, 22220053-3, 22220060-3, 22220061-3, 22220054-3, 22220085-3 (compatible without IMAGE1 S technologies CLARA, CHROMA, SPECTRA*)</td>
</tr>
<tr>
<td>LINK video outputs</td>
<td>1x</td>
</tr>
<tr>
<td>Power supply</td>
<td>100–120 VAC/200–240 VAC</td>
</tr>
<tr>
<td>Power frequency</td>
<td>50/60 Hz</td>
</tr>
<tr>
<td>Protection class</td>
<td>I, CF-Defib</td>
</tr>
<tr>
<td>Dimensions w x h x d</td>
<td>305 x 54 x 320 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>1.86 kg</td>
</tr>
</tbody>
</table>

* SPECTRA A: Not for sale in the U.S.

** SPECTRA B: Not for sale in the U.S.
### IMAGE1 S Camera Heads

#### For use with IMAGE1 S Camera System

**IMAGE1 S CONNECT Module TC 200EN, IMAGE1 S H3-LINK Module TC 300**

and with all IMAGE1 HUB™ HD Camera Control Units

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**KARL STORZ FULL HD Monitor**

<table>
<thead>
<tr>
<th>KARL STORZ HD Flat Screens</th>
<th>Version</th>
<th>Order No.</th>
<th>Screen diagonal</th>
<th>Max. screen resolution</th>
<th>Video input</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color systems PAL/NTSC</td>
<td></td>
<td></td>
<td></td>
<td>1920 × 1080</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wall mounted with VESA 100-adaption</td>
<td>9626 NB</td>
<td>26&quot;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pedestal</td>
<td>9626 SF</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**IMAGE1 S H3-Z Three-Chip FULL HD Camera Head,**

50/60 Hz, IMAGE1 S compatible, progressive scan, soakable, gas- and plasma-sterilizable, with integrated Parfocal Zoom Lens, focal length \( f = 15–31 \text{ mm} \) (2x), 2 freely programmable camera head buttons, for use with IMAGE1 S and IMAGE1 HUB™ HD/HD

### Specifications:

<table>
<thead>
<tr>
<th>IMAGE1 FULL HD Camera Heads</th>
<th>IMAGE1 S H3-Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product no.</td>
<td>TH 100</td>
</tr>
<tr>
<td>Image sensor</td>
<td>3x ( \frac{1}{3} )&quot; CCD chip</td>
</tr>
<tr>
<td>Dimensions w x h x d</td>
<td>39 x 49 x 114 mm</td>
</tr>
<tr>
<td>Weight</td>
<td>270 g</td>
</tr>
<tr>
<td>Optical interface</td>
<td>integrated Parfocal Zoom Lens, ( f = 15–31 \text{ mm} ) (2x)</td>
</tr>
<tr>
<td>Min. sensitivity</td>
<td>F 1.4/1.17 Lux</td>
</tr>
<tr>
<td>Grip mechanism</td>
<td>standard eyepiece adaptor</td>
</tr>
<tr>
<td>Cable</td>
<td>non-detachable</td>
</tr>
<tr>
<td>Cable length</td>
<td>300 cm</td>
</tr>
</tbody>
</table>
Cold Light Fountain XENON 300 SCB

Cold Light Fountain XENON 300 SCB with built-in antifog air-pump, and integrated KARL STORZ Communication Bus System SCB power supply: 100–125 VAC/220–240 VAC, 50/60 Hz including:
- Mains Cord
- SCB Connecting Cable, length 100 cm
- 20133027 Spare Lamp Module XENON with heat sink, 300 watt, 15 volt
- 20133028 XENON Spare Lamp, only, 300 watt, 15 volt

Fiber Optic Light Cable

Fiber Optic Light Cable, with straight connector, diameter 3.5 mm, length 300 cm

AUTOCON® II 400 SCB

AUTOCON® II 400 High End, Set SCB power supply 220 - 240 VAC, 50/60 Hz, HF connecting sockets: Bipolar combination, Multifunction, Unipolar 3-pin + Erbe Neutral electrode combination 6.3 mm, jack and 2-pin, System requirements: SCB R-UI Software Release 20090001-43 or higher including:
- AUTOCON® II 400, with KARL STORZ SCB Mains Cord
- SCB Connecting Cable, length 100 cm
Data Management and Documentation
KARL STORZ AIDA® – Exceptional documentation

The name AIDA stands for the comprehensive implementation of all documentation requirements arising in surgical procedures: A tailored solution that flexibly adapts to the needs of every specialty and thereby allows for the greatest degree of customization.

This customization is achieved in accordance with existing clinical standards to guarantee a reliable and safe solution. Proven functionalities merge with the latest trends and developments in medicine to create a fully new documentation experience – AIDA.

AIDA seamlessly integrates into existing infrastructures and exchanges data with other systems using common standard interfaces.

WD 200-XX* AIDA Documentation System, for recording still images and videos, dual channel up to FULL HD, 2D/3D, power supply 100-240 VAC, 50/60 Hz including:
- USB Silicone Keyboard, with touchpad
- ACC Connecting Cable
- DVI Connecting Cable, length 200 cm
- HDMI-DVI Cable, length 200 cm
- Mains Cord, length 300 cm

WD 250-XX* AIDA Documentation System, for recording still images and videos, dual channel up to FULL HD, 2D/3D, including SMARTSCREEN® (touch screen), power supply 100-240 VAC, 50/60 Hz including:
- USB Silicone Keyboard, with touchpad
- ACC Connecting Cable
- DVI Connecting Cable, length 200 cm
- HDMI-DVI Cable, length 200 cm
- Mains Cord, length 300 cm

*XX Please indicate the relevant country code (DE, EN, ES, FR, IT, PT, RU) when placing your order.
Workflow-oriented use

Patient
Entering patient data has never been this easy. AIDA seamlessly integrates into the existing infrastructure such as HIS and PACS. Data can be entered manually or via a DICOM worklist. All important patient information is just a click away.

Checklist
Central administration and documentation of time-out. The checklist simplifies the documentation of all critical steps in accordance with clinical standards. All checklists can be adapted to individual needs for sustainably increasing patient safety.

Record
High-quality documentation, with still images and videos being recorded in FULL HD and 3D. The Dual Capture function allows for the parallel (synchronous or independent) recording of two sources. All recorded media can be marked for further processing with just one click.

Edit
With the Edit module, simple adjustments to recorded still images and videos can be very rapidly completed. Recordings can be quickly optimized and then directly placed in the report. In addition, freeze frames can be cut out of videos and edited and saved. Existing markings from the Record module can be used for quick selection.

Complete
Completing a procedure has never been easier. AIDA offers a large selection of storage locations. The data exported to each storage location can be defined. The Intelligent Export Manager (IEM) then carries out the export in the background. To prevent data loss, the system keeps the data until they have been successfully exported.

Reference
All important patient information is always available and easy to access. Completed procedures including all information, still images, videos, and the checklist report can be easily retrieved from the Reference module.
Equipment Cart

29003 LC  **Equipment Cart LC**, including:

**Basic Equipment Cart**, rides on 4 anti-static dual wheels, 2 equipped with locking brakes, 2 fixed shelves, 1 drawer unit with lock, 1 set of non-sliding stands, 1 camera head mount including integrated small cable conduit in both boom,

**Powerbox** with 12-times socket board 12 grounding plugs

**Dimensions:**

Equipment cart: 700 mm x 1450 mm x 686 mm (w x h x d)
Shelf: 630 mm x 480 mm (w x d)
Caster diameter: 125 mm