Neurosurgery of the future

From trephination to robotics and laser surgery

Performance Report 2019–2021

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DEPARTMENT OF NEUROSURGERY

MEDICAL UNIVERSITY OF VIENNA

Vienna Healthcare Group
University Hospital Vienna

Neurosurgery of the future

Performance Report 2019–2021

Contents

Profile:
Karl Rössler studied medicine in Vienna and trained as a postgraduate in clinical and experimental neuropathology at the University of Vienna's Neurological Institute under Herbert Budka and Hans Lassmann.
He completed his specialist training with Wolfgang Koos at the Department of Neurosurgery in Vienna, where he obtained his postdoctoral teaching qualification (Venia Docendi) in neurosurgery and was awarded the title of University Professor by the Austrian Federal Ministry of Education, Science and Research.
He subsequently headed the Department of Neurosurgery at the Specialist Feldkirch Hospital in Vorarlberg before moving to the Friedrich Alexander University (FAU) Erlangen-Nuremberg as Deputy Clinical Director of the Department of Neurosurgery.

Karl Rössler, Head of Department

» Foreword

It was with great pleasure, and full of energy, that I took over the professorship of Neurosurgery at MedUni Vienna and the management of the Department of Neurosurgery at MedUni Vienna and University Hospital Vienna on July 1, 2019. Before taking up my new post, I was Deputy Clinical Director of the University Clinic for Neurosurgery at the Friedrich Alexander University Erlangen-Nuremberg.

In recent years, my research interests have specifically centred on neuronavigation and intraoperative imaging in epilepsy surgery, brain tumour surgery and vascular neurosurgery at the University Hospital Erlangen, which is one of the world's leading centres of excellence for intraoperative imaging. Particularly in the field of epilepsy and glioma surgery, I achieved various landmarks for the application of intraoperative, functional and metabolic MRI. I would like to continue to pursue these research projects at the newly established intraoperative MRI centre at the Department of Neurosurgery at MedUni Vienna and University Hospital Vienna, with the aim of establishing an international centre of excellence for intraoperative imaging in neurosurgery, in partnership with the Department of Biomedical Imaging and Image-guided Therapy.

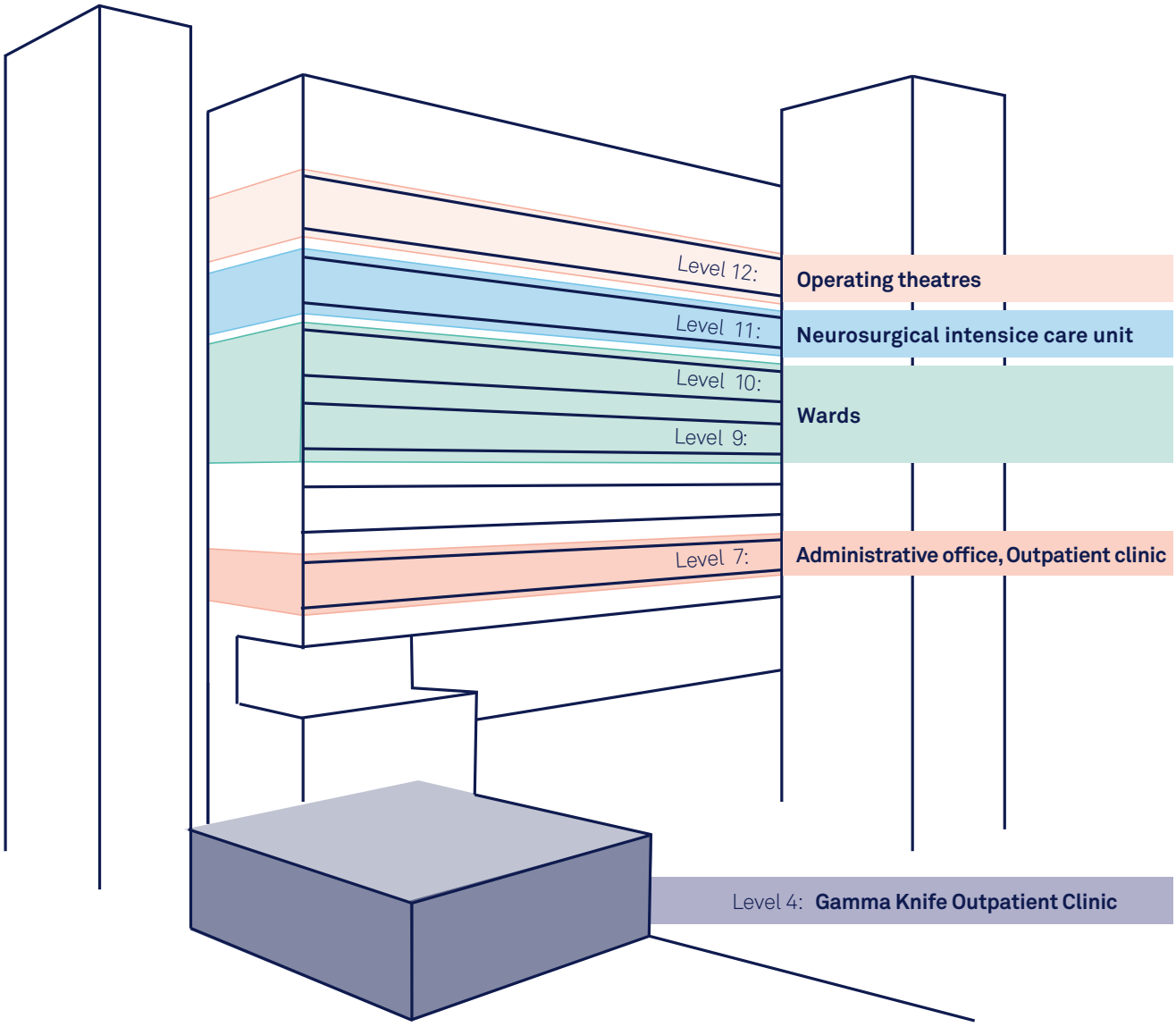
Beyond that, I would also like to expand and deepen interdisciplinary cooperation at MedUni Vienna and implement the establishment of the Comprehensive Center for Clinical Neurosciences.
In particular, through closer cooperation with the University Departments of Neurology and Psychiatry, the Division of Neuropathology and Neurochemistry of the University Department of Neurology and the Center for Brain Research, findings from basic research for neurosurgical therapies of common diseases such as epilepsy, Parkinson's disease or depression are to be increasingly incorporated and used for new therapies.

International networking of clinic, research and further education of young colleagues as well as the treatment of patients with rare neurosurgical diseases will form another focus. This will increasingly be used in oncological and vascular neurosurgery (including the subareas of endovascular neurosurgery and Gamma Knife), with a view to participating in international multicentre studies.

Location

Since 1984, the University Department of Neurosurgery, planned by Wolfgang Koos, has been located in its own building complex within the "Kliniken am Südgarten" on the grounds of University Hospital Vienna and MedUni Vienna. The organisational units of our clinic are distributed on eight level:

Level 4	**Radiosurgery:** A complete radiosurgical Gamma Knife treatment unit is located here. In addition to the treatment room (OP6) and the planning room, there is a separate reception desk and the Gamma Knife Outpatient Clinic.
Level 5	**Main entrance** with an in-house porter who directs patients to the correct level and handles incoming telephone calls and service calls. This level also houses a seminar room for education, training and meetings, as well as the office of the clinical psychologists.
Level 6	**Link** to the **Department of Pediatrics and Adolescent Medicine, as well as the Department of Pediatric and Adolescent Surgery** and to the **main building of University Hospital Vienna** via the Arnold Pollak bridge.
Level 7	This level contains the **Department's administrative office,** the general outpatient clinic with reception desk, and a stereotactic operating theatre (OP4).
Level 8	**Intraoperative MRI (3T)** and Neurosurgical Interventional Angiography. This level was completely remodelled in 2020. It contains an operating theatre with intraoperative MRI (OP7) and a room for endovascular procedures complete with 4D angiography equipment (OP5). One of the Department of Biomedical Imaging and Image-guided Therapy's computer tomography units is also housed here.
Level 9, 10	Our two **wards,** each with a four-bed observation room, are located on these levels.
Level 11	**Neurosurgical intensive care unit,** where up to ten patients are cared for in close cooperation with the Department of Anesthesia, Critical Care and Pain Medicine.
Level 12	The location of our **operating theatre wing** with three fully equipped neurosurgical operating theatres.


Level 12:
Operating theatres
Level 11:
Neurosurgical intensice care unit
Level 10:
Level 9:
Wards
Level 7:
Administrative office, Outpatient clinic
Level 4: Gamma Knife Outpatient Clinic

Employees as of January 1, 2022

Karl Rössler
Head of Department

Christian Dorfer
Deputy Head of Department and
Chief Physician

Christian Matula
2nd Deputy Head of Department
and Chief Physician

Stefan Wolfsberger
Senior Physician
Chair of the Department of Neurosurgery at
the University of Graz since 1 March 2022

Andrea Reinprecht
Executive Senior Physician

Georg Widhalm
Deputy Executive
Senior Physician

Departmental management

Gerhard Bavinzski

Alexander Bertalanffy

Walter Saringer

Josa Frischer
Human Resources

Brigitte Gatterbauer
Coordination of Medical and Nursing Staff

Johannes Herta
Outpatient Clinic Manager

Magnus Kueß
Quality Management

Klaus Novak
Stereotactic Neurosurgery

Senior physicians

Philippe Dodier

Arthur Hosmann

Barbara Kiesel

Alexander Micko
Specialist at the Department of Neurosurgery
at the University of Graz since March 1 2022

Matthias Millesi

Elisabeth Strasser

Lisa Wadiura

Wei-Te Wang

Aygül Wurzer

Medical specialists

Barbara Anton

Malgorzata Wieczorkowski

Ward doctors

Lötsch Daniela

Head of the Neurosurgical Research Laboratory

Anna Cho

Friedrich Erhart

Dorian Hirschmann

Farjad Khalaveh

Mario Mischkulnig

Matthias Tomschik

Jonathan Wais

Fabian Winter

Doctors in residency/ specialist training

Gilbert Hangel

Intraoperative MRI Physicist

Andreas Ertl

Medical Physicist Gamma Knife

» Organisation and administration of the Department

The central contact point at our clinic is the Department's administrative office, which is where all the various different threads involving the running of the Department and personnel matters come together. Its main tasks include handling inbound and outbound calls to/from our Department, looking after the electronic duty roster and managing scientific research projects.

Directly adjacent to the Department administrative office is the executive administrative office, which supports Professor Rössler in his organisational and clinical activities and, among other things, handles private insurance billing and archiving of histological findings. In addition, there is a surgery planning office, set up by Professor Rössler, which looks after of all aspects of patient management. This covers everything from contacting patients for pre-registration ahead of their operation in our outpatient department to planning inpatient admissions and coordinating operation dates.
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Department and executive administrative office team:
Ingeborg Wagner (left), executive office manager
Lisa Gäcklein (centre), Susanne Peschl (right)

OP planning office team:
Larissa Riedl-Zwickl (left), Dagmar Meyer (right)

» Inpatient treatment

We have two standard wards and an intensive care unit for the treatment of inpatients.
Each ward has its own administrative office. The standard wards each comprise 23 beds arranged in two-bed and three-bed rooms, as well as one four-bed observation room. A team of qualified health care and nursing staff provides professional, round-the-clock care for our patients.

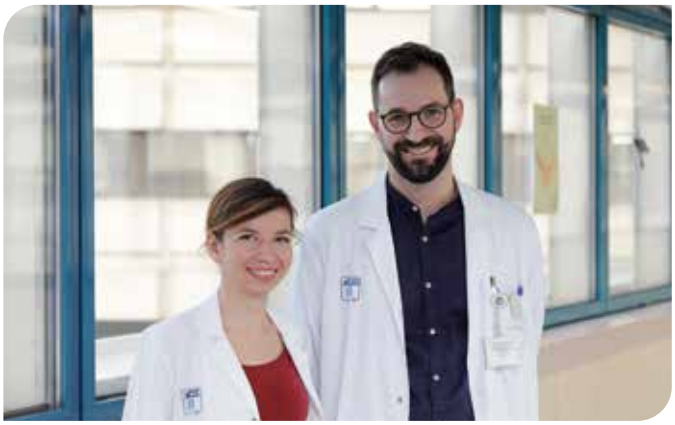
In the neurosurgical intensive care unit, up to ten patients are looked after in close cooperation with the Department of Anesthesia, Critical Care and Pain Medicine.
On each of these wards, the care team is supported by a team of physiotherapists, occupational therapists, speech therapists and clinical psychologists to ensure the best possible level of care for patients both before and after their operation.

Ward Managers, Nursing Ward E09:
Alfred Perger, Katharina Hochsteger

Ward Managers, Nursing Ward E10:
Babette Hladik, Franz Fürst

Ward Managers, Nursing Ward E11:
Martin Höllriegel (left), Dieter Etzenberger (right)

Our team of physiotherapists, occupational therapists and speech therapists (from left to right): Christoph Patak (physio), Natascha Doubek (physio), Barbara Binder (speech), Carina Lehner (occupational), Susanne Pigel (physio), Johanna Gort (speech), Bettina Hamerl (occupational), Jakob Bayer (physio)



Clinical psychologists:
Marlene Weberberger, Richard Altinger

Photos: Wei-Te Wang

» Clinical outpatient services

The Neurosurgery Outpatient Clinic and the Gamma Knife Outpatient Clinic are open to patients from Monday to Friday. In conjunction with the emergency outpatient clinic at MedUni Vienna and University Hospital Vienna, 24-hour neurosurgical care is guaranteed 365 days a year.

Photo: Wei-Te Wang

Outpatient Clinic team (from left to right): Sanja Pavosevic, Aneta Ehrmann, Mirsada Hamzic, Ursula Haas

Between 2019 and 2021, more than 30,000 outpatient contacts were recorded. Headed by Johannes Herta and Walter Saringer with the dedicated support of our outpatient secretaries and nursing staff, the Neurosurgical Outpatient Clinic plays an important role in the provision of acute and long-term care for our patients. In addition to diagnosis of neurosurgical diseases and recording indications for operations, postoperative outpatient follow-up care is also carried out at the facility. Outpatient care is provided in the specialist outpatient clinics, drawing closely on our research activities. The goal is to achieve better therapy outcomes through optimised treatment concepts, in close consultation with the other departments we work with.

Outpatient contacts 2019–2021

	2019	2020	2021
General outpatient clinic	1,700	1,315	1,130
Paediatric neurosurgery (NS)	1,028	760	900
Skull base surgery	1,915	1,831	2,201
Spinal NS	1,496	1,321	1,226
Vascular NS	1,650	1,496	1,878
Functional NS and pain	264	198	272
Oncological NS	892	601	536
Gamma Knife Outpatient Clinic	2,048	1,541	1,415
Consultant neurosurgery	536	590	781
Total	**11,498**	**9,653**	**10,339**

About 10 % of patients who attend require acute treatment. This is provided through our outpatient clinic and on the basis of our consultations at the emergency outpatient clinic, at the trauma surgery shock room and at the paediatric outpatient department. Here, professional care is provided for patients with acute clinical conditions, such as intracranial haemorrhages or acute herniated discs.

Located at Klinik am Südgarten, Währinger Gürtel 18–20, 1090 Vienna, the **Department of Neurosurgery's outpatient clinic at University Hospital Vienna** and **MedUni Vienna** is open from **Monday to Friday** from **07:30 am to 3:00 pm.** It is located on **Level 7.** **Appointments** for the outpatient clinic can be arranged from **Monday to Friday from 1:30 pm to 3:00 pm** by telephone on **+43 (0)1 40400-25700** or on level 7 at the Outpatient Clinic reception desk.

The **Gamma Knife Outpatient Clinicis** open from **Monday to Friday 10:00 am to 3:00 pm.** It is located on **Level 4.** **Appointments** for the clinic can be made from **Monday to Friday from 1:30 pm to 3:00 pm** by telephone on **+43 (0)1 40400-45510.**

OUTPATIENT CLINIC		Opening hours and heads of clinic
	General Outpatient Clinic and Post-Inpatient Care	Monday–Friday: 8:30 am–3:00 pm Johannes Herta
SPECIAL OUTPATIENT CLINICS	**Gamma Knife Outpatient Clinic**	Monday–Friday: 10:00 am–3:00 pm Brigitte Gatterbauer Josa Frischer
	Vascular Outpatient Clinic	Monday: 8:30 am–3:00 pm Gerhard Bavinzski
	Spine Outpatient Clinic	Tuesday: 8:30 am–3:00 pm Walter Saringer
	Skull Base Outpatient Clinic	Wednesday: 8:30 am–3:00 pm Christian Matula
	Neuro-oncology Outpatient Clinic	Thursday : 8:30 am–3:00 pm Georg Widhalm
	Functional Neurosurgery Outpatient Clinic	Friday: 8:30 am–3:00 pm Klaus Novak
	Epilepsy Surgery Outpatient Clinic	Friday: 8:30 am–3:00 pm Christian Dorfer
	Paediatric Outpatient Clinic	Friday: 8:30 am–3:00 pm Andrea Reinprecht Christian Dorfer

» Clinical operational services

A total of seven surgical units are available for the treatment of our patients. Of these, 4 operating rooms are fully equipped specifically for general neurosurgical procedures. From microscopes and endoscopes to neuromonitors, lasers, fluorescence surgery systems and intraoperative MRI, a full spectrum of state-of-the-art equipment is available.

A team of specialized certified health care and nursing staff, radiological technicians and operating theatre nurses ensure that the often complex neurosurgical interventions run smoothly.

Postoperative Care Ward managers with Karl Rössler: Susanne Raberger and Martin Rauchberger

Photo: Wei-Te Wang

Neurosurgical operation/ Neurosurgery theatre

Photo: Wei-Te Wang

Endovascular procedures are performed in a specially designed operating theatre with a state-of-the-art 4D biplanar angiography system.

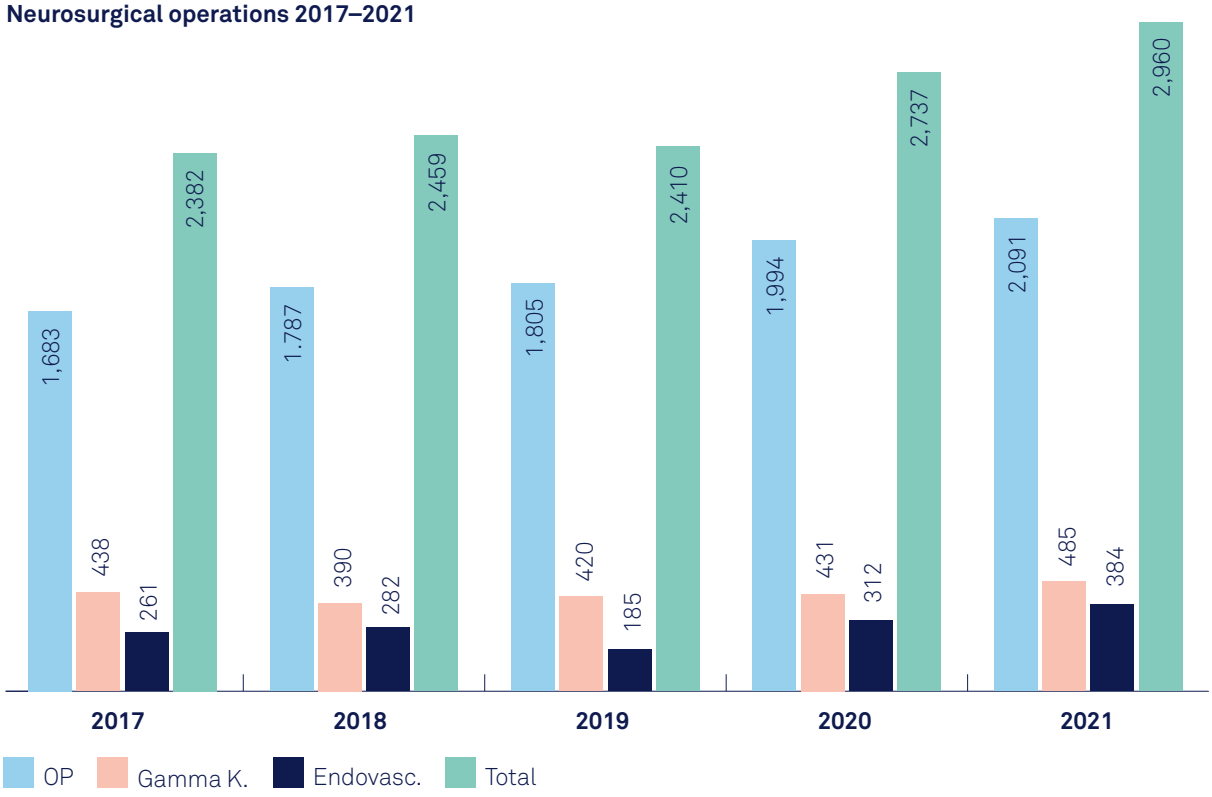
Radiosurgical irradiation is performed in our Elekta Gamma Knife facility using the latest model of this stereotactic radiation unit.

Endovascular operation/theatre Photo: Wei-Te Wang

Gamma Knife Photo: Alexander Bertalanffy

Every year, our Department performs more than 2,000 surgical procedures.
The number of operations has increased continuously in recent years. More than 70 % of these procedures are conventional neurosurgical operations.
The remainder is divided between endovascular procedures and radiosurgical irradiation with the Gamma Knife.

Neurosurgical operations 2017–2021




PERFEXION

» Clinical and Scientific Working Groups

Brain tumour surgery

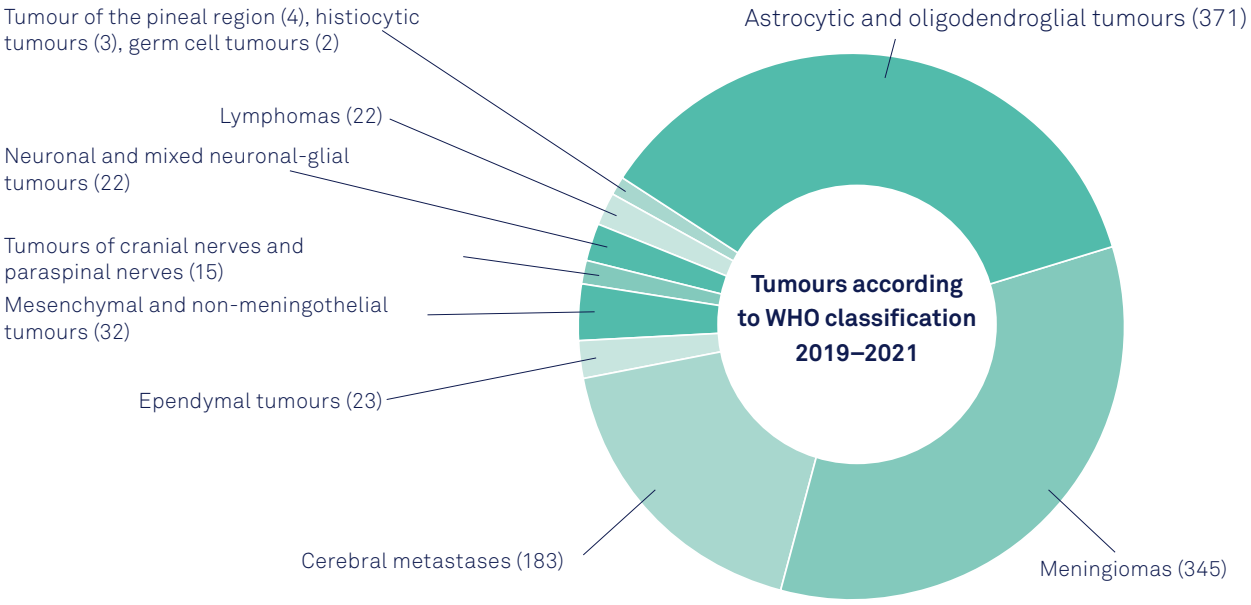
From finger preparation to image-guided surgery with navigation, robotics and intraoperative MRI

Headed by: Georg Widhalm
Deputy: Barbara Kiesel

In accordance with our Department's specialist focus, brain tumours represent one of the most frequent interventions at the Department of Neurosurgery Vienna. Over the past few years, state-of-the-art molecular genetic analysis has revolutionised the diagnosis of brain tumours.

It enables more precise diagnosis, better prognosis assessment and optimisation of postoperative therapy management in line with the principles of precision medicine.

Most common tumour entities treated at the Department of Neurosurgery Vienna, 2019–2021:



	2019	2020	2021	2019–2021
Astrocytic and oligodendroglial tumours	115	123	133	**371**
Meningiomas	125	112	108	**345**
Cerebral metastases	65	62	56	**183**
Ependymal tumours	12	5	6	**23**
Mesenchymal and non-meningothelial tumours	10	12	10	**32**
Cranial nerve and paraspinal nerve tumours	8	4	3	**15**
Neuronal and mixed neuronal-glial tumours	7	6	9	**22**
Lymphomas	5	7	10	**22**
Tumours of the pineal region		1	3	**4**
Histiocytic tumours		1	2	**3**
Germ cell tumours		1	1	**2**
Total	**347**	**334**	**341**	**1022**

Significant progress has been made in recent years when it comes to preoperative planning, surgical treatment, precision diagnosis and postoperative follow-up support for brain tumour patients. This optimal patient care is only possible through close cooperation with other disciplines.

Preoperative assessment and planning

In the context of preoperative assessment and surgical planning, imaging diagnostics is essential – which is why close cooperation with the Department of Biomedical Imaging and Image-guided Therapy is a prerequisite for optimal patient management.

An MRI protocol was developed in cooperation with the Department of Biomedical Imaging and Image-guided Therapy in order to optimize and standardize preoperative assessment. The process now includes diagnostic (MR spectroscopy, perfusion MRI, ASL, SWI), anatomical, metabolic (MR spectroscopy)and functional (FTI, DTI) imaging. Meanwhile, positron emission tomography (PET) examinations provide further metabolic information about tumours. In the case of tumours near functional brain areas, such as motor control and speech, functional MRI can visualize these areas, optimizing preoperative intervention planning and, as a result, enhance the safety of the intervention. The close cooperation with the Department of Neurology primarily centres on preoperative assessment of epileptic seizures and optimization of seizure therapy, since these are a frequent common symptom of brain tumour disease. Additional imaging procedures such as high-field/7 Tesla MRI and special MRI sequences are also commonly performed as part of clinical trials.

Surgical treatment

Neuronavigation is nowadays an indispensable tool for tumour resections and biopsies. Image data acquired before the operation is fused and integrated into the neuronavigation system and the neurosurgical microscope to ensure maximum intraoperative safety and precision. In addition, intraoperative neurophysiologic monitoring provides another technique for monitoring and maintaining neurological functions while the surgical procedure is carried out.

Since 2007, fluorescence technology with 5-aminolevulinic acid (5-ALA) has been used to improve visualization of tumour borders during surgery in order to help achieve maximum tumour resection.

An additional optimization of the resection of brain tumours is made possible by the use of a so-called interoperative MRI. This allows any residual tumour to be detected during surgery and subsequently resected. The use of this innovative technique has increased the rate of maximum safe removal of brain tumours and thus further improved the prognosis.

Postoperative follow-up

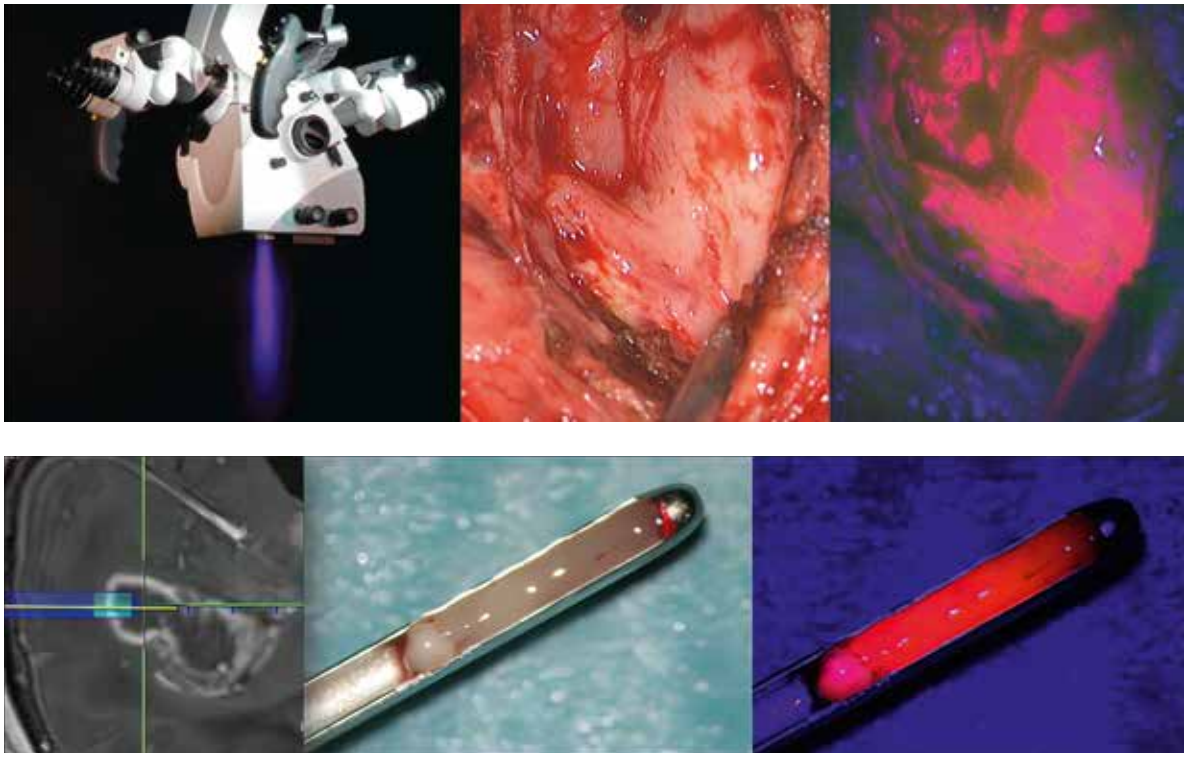
Directly after a brain tumour resection, patients are cared for postoperatively in our neurosurgical intensive care unit. For resection control, patients with brain tumours and cerebral metastases in particular receive an early postoperative MRI. Following brain tumour surgery, each patient's notes are discussed in the interdisciplinary Tumour Board. (see p. 70). This allows an individual treatment plan to be drawn up for to ensure optimal post-operative brain tumour therapy.

Photo: Department of Neurosurgery/ feelimage

Research highlights

5-ALA fluorescence

Improved visualization of brain tumours during neurosurgical interventions can be achieved thanks to pioneering advances in fluorescence technology using 5-ALA. Until recently, this technique had largely only been used to treat fast-growing brain tumours. But over the past few years, the Department of Neurosurgery in Vienna has become one of the world's leading centres of research into new applications of 5-ALA fluorescence technology. To date, more than 1,500 procedures have been performed at our clinic using this fluorescence technique and the results have been published in several renowned journals. Various research collaborations with respected international institutions have also been established.



Open surgery (top) and biopsy (bottom) of a malignant brain tumour. Tumour under normal light (centre) and 5-ALA fluorescence (right).

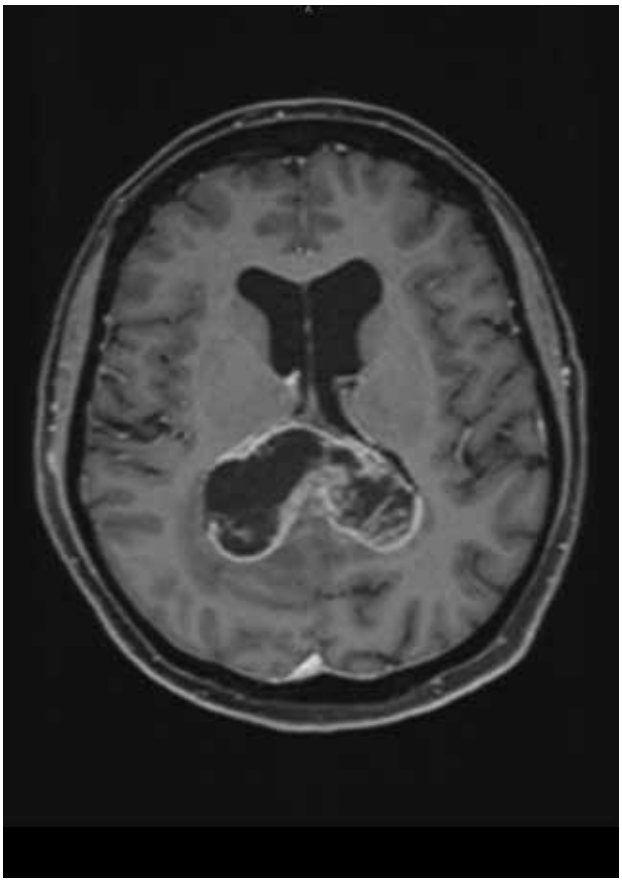
Photos: Neurosurgery

Tumour Immunology

In the field of tumour immunology – as part of the Department of Neurosurgery's neuro-oncological scientific activity – findings from research into an innovative, experimental form of cancer immunotherapy against glioblastomas were published in 2019–2021. The Department of Neurosurgery at MedUni Vienna and University Hospital Vienna played a key role in conducting an Austria-wide phase II clinical trial and in the associated immunological and molecular biological research. The scientific work was carried out in a collaborative effort involving numerous institutions – including the St. Anna Children's Cancer Research Institute's Laboratory for Tumour Immunology (which developed the immunotherapy technology), the Division of Neuropathology and Neurochemistry, the Division of Oncology and the Center for Cancer Research at MedUni Vienna.

Tumour heterogeneity

Glioblastomas are the most common – and most aggressive – brain tumours found in adults. Despite multimodal therapy, just half of the patients survive longer than one year, with under 10 % living longer than three years after diagnosis. The phenomenon known as tumour heterogeneity has already been analysed in glioblastomas at DNA level. In contrast, epigenetics – i.e. the gene regulatory mechanisms that do not change the sequence of the DNA itself, but rather the way that it is interpreted – remained largely unnoticed for a long time. Johanna Klughammer (CeMM Research Center for Molecular Medicine) and Barbara Kiesel (Department of Neurosurgery) have comprehensively investigated these epigenetic changes for the first time. The results of this study were published in the journal Nature Medicine (IF 2021: 87,241) in an article entitled "The DNA methylation landscape of glioblastoma disease progression shows extensive heterogeneity in time and space". Last but not least, this study provides an example of how samples collected in routine clinical practice can be used for genome-wide molecular analyses in order to better understand complex diseases and gain the insights needed to draw up personalized therapies.



MRI of a typical glioblastoma

Photo: Neuroradiology

Neurovascular/Endovascular Working Group

Vascular neurosurgery: Combination of catheter and microsurgery for vascular malformations of the brain

Headed by: Gerhard Bavinzski
Deputy: Wei-Te Wang, Philippe Dodier
Team: Wolfgang Marik (Department of Biomedical Imaging and Image-guided Therapy), Wolfgang Serles (Department of Neurology)

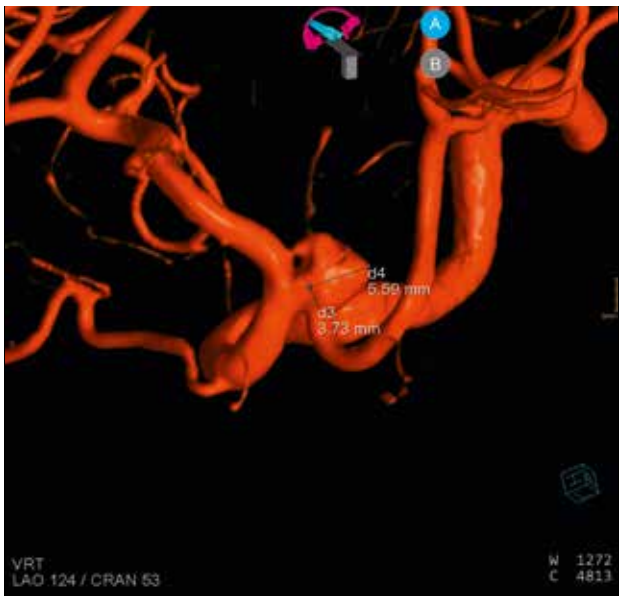
Vascular and endovascular neurosurgery focuses on the treatment of vascular diseases of the central nervous system and its feeding arteries. The majority of procedures are performed to treat ready-to-bleed vascular diseases of the brain, such as aneurysms, angiomas and dural arteriovenous fistulas. Sophisticated microsurgery and neurointerventional techniques are available for the treatment of these diseases. The effectiveness of microsurgical clipping of cerebral aneurysms has been further optimized with the support of cutting-edge intraoperative imaging techniques such as intraoperative angiography, indocyanine green (ICG) videoangiography and endoscopy.

Photo: Wei-Te Wang

In endovascular treatment of cerebral aneurysms, major advances in stent technology mean that it is now possible to safely treat numerous aneurysms – which are inherently unsuitable for this technique due to their broad-based morphology – by using stent-assisted Coilembolization or flow-modifying stents (flow diverters). When it comes to treating complex aneurysms, additional sophisticated techniques performed in cerebral bypass surgery are also available, enabling safe aneurysm closure and bypass protection in the most difficult cases. A multimodal treatment concept is also available for treating cerebral angiomas and dural arteriovenous fistulas. In such cases, microsurgery, endovascular therapy and neuroradiosurgery using Gamma Knife are coordinated to allow the treatment of complex angiomas with low morbidity.

Besides the treatment of haemorrhage-prone cerebral vascular diseases, the treatment of ischaemic cerebral vascular diseases, in particular stroke therapy, is becoming increasingly important in view of an ageing population and the opportunities opened up by recent technological advances.
Both endovascular (thrombectomy, primarily offered by the Division of Cardiovascular and Interventional Radiology and the Department of Neurology) and microsurgical treatment options (EC-IC bypass) are available for the treatment of ischaemic strokes.

The treatment concepts for the numerous cerebral vascular diseases treated at the Department of Neurosurgery are discussed at a monthly interdisciplinary Vascular Board meeting (p. 70), which is attended by specialists working in neurosurgery, neurology and neuroradiology, as well as postgraduate students from the Clinical Neurosciences (CLINS) training programme.



Cerebral artery aneurysm:
Digital reconstruction of a brain artery angiography

Photo: Neurosurgery

Clinical services

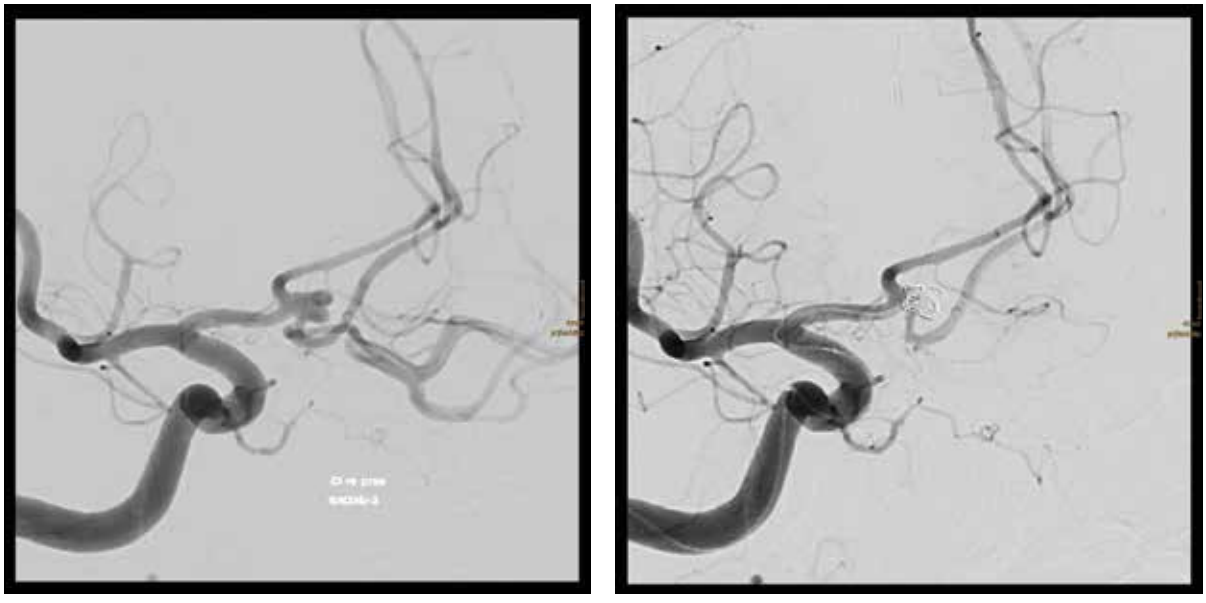
A total of 1,133 vascular and endovascular procedures and examinations were performed at the Department of Neurosurgery between 2019 and 2021. Diagnostic angiographies accounted for the largest share (525 procedures, or 46 % of the total; incl. spasmolysis, balloon compression, DSA-digital subtraction angiography with an option of immediate embolization during the same procedure) followed by multimodal aneurysm treatments (467; 41 %), and multimodal angioma treatments (94; 8 %).

Extra-intracranial bypasses, another focus of our research group, were performed 15 times during this three-year period in connection with "Misery-perfusion syndromes" as well as complex aneurysm therapies (combined procedure of bypass and therapeutic vessel closure).

		2019	2020	2021	Total	%
Aneurysm	Clipping	46	56	58	160	41 %
	Coil embolisation and stent/ flow diverter	74	104	123	301	
	Combined (bypass and PAO)	3	1	2	6	
Angioma	AVM resection and AV fistula closure	16	14	15	45	8 %
	Embolisation	6	14	29	49	
Cavernoma	Resection	8	15	9	32	3 %
Cerebral ischaemia	EC-IC Bypass	4	7	4	15	2 %
Diagnostics	DSA and spasmolysis	102	193	230	525	46 %
Total		**259**	**404**	**470**	**1,133**	**100 %**

Establishing a vascular on-call service

2019, when Karl Rössler took over the professorship of Neurosurgery, the new roster was established, with the aim of strengthening the positioning of the Department as a reference centre for aneurysms and other vascular emergencies. An additional on-call service was established to ensure uninterrupted access to treatment for subarachnoid haemorrhages on all haemorrhage days assigned to University Hospital Vienna.



Embolisation of an Arteria communicans anterior aneurysm

Photo: Neurosurgery

Epilepsy Surgery Working Group

Epilepsy surgery: Modern imaging, surgical electroencephalography and laser navigation are all playing a part in the fight against epilepsy

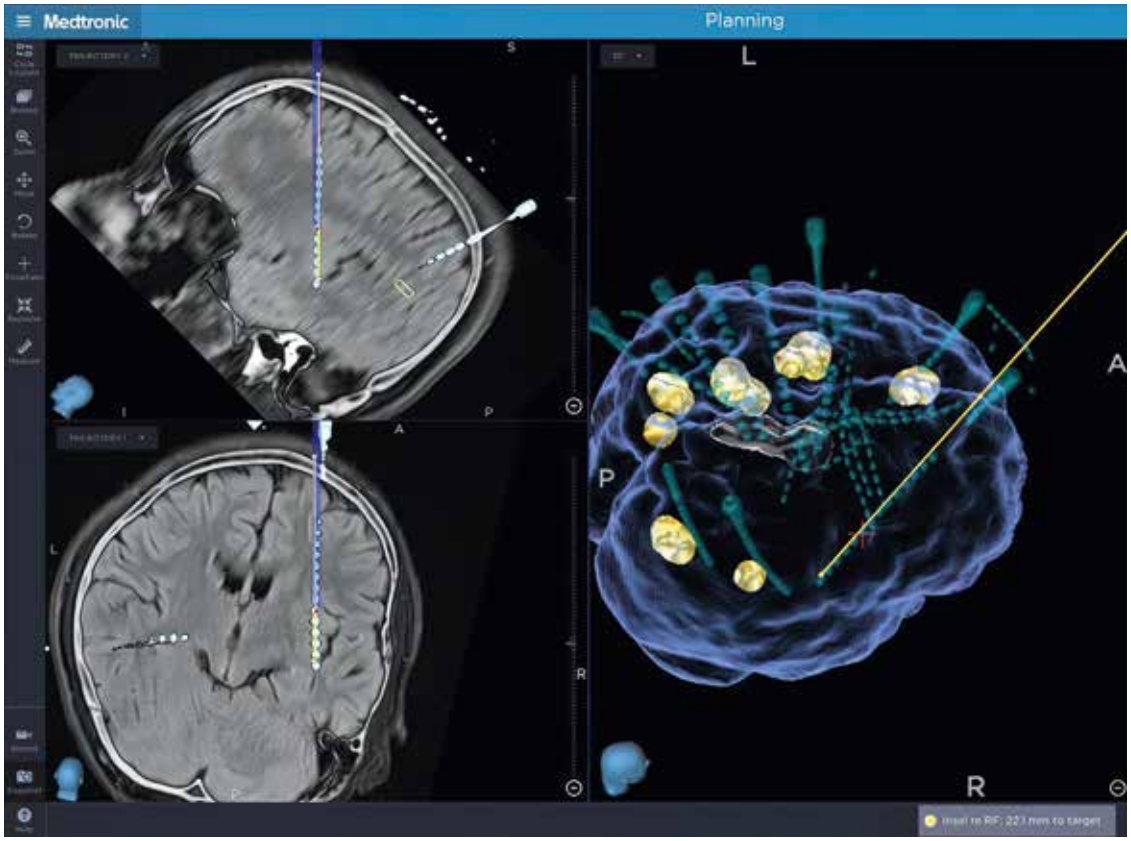
Headed by: Karl Rössler
Deputy: Christian Dorfer

Epilepsy affects about 1 % of the world's population. Found in all age groups, it can severely limit the quality of life of patients with the condition. Despite the availability of effective antiepileptic medication, around one third of people with the disease cannot lead seizure-free lives. In cases like these, the effectiveness of epilepsy surgery as a therapeutic option has been indisputably proven in recent years.

A separate specialist outpatient clinic for epilepsy surgery provides highly specialised care for all epilepsy surgery patients, both preoperatively and during long-term follow-up. Complex cases are discussed in monthly interdisciplinary meetings. For many years now, our Department has worked closely with the epilepsy units of the Department of Pediatrics and Adolescent Medicine, the Department of Neurology, the Department of Biomedical Imaging and Image-guided Therapy and the Neurological Rehabilitation Centre Rosenhügel.

Robot-assisted implantation of depth electrodes

Photo: Stefan Wolfsberger



Depth electrode trajectories in child patient with tuberous sclerosis and refractory epilepsy (tubers: yellow)

Photo: Karl Rössler

Between 2019 and 2021, a total of 192 epilepsy surgery procedures were performed at the Department of Neurosurgery, of which 109 (57 %) were on adults and 83 (43 %) on paediatric patients. The age range varies from 0 to 62 years, with an average age of 7 years for pediatric patients and 25 years for adult patients.

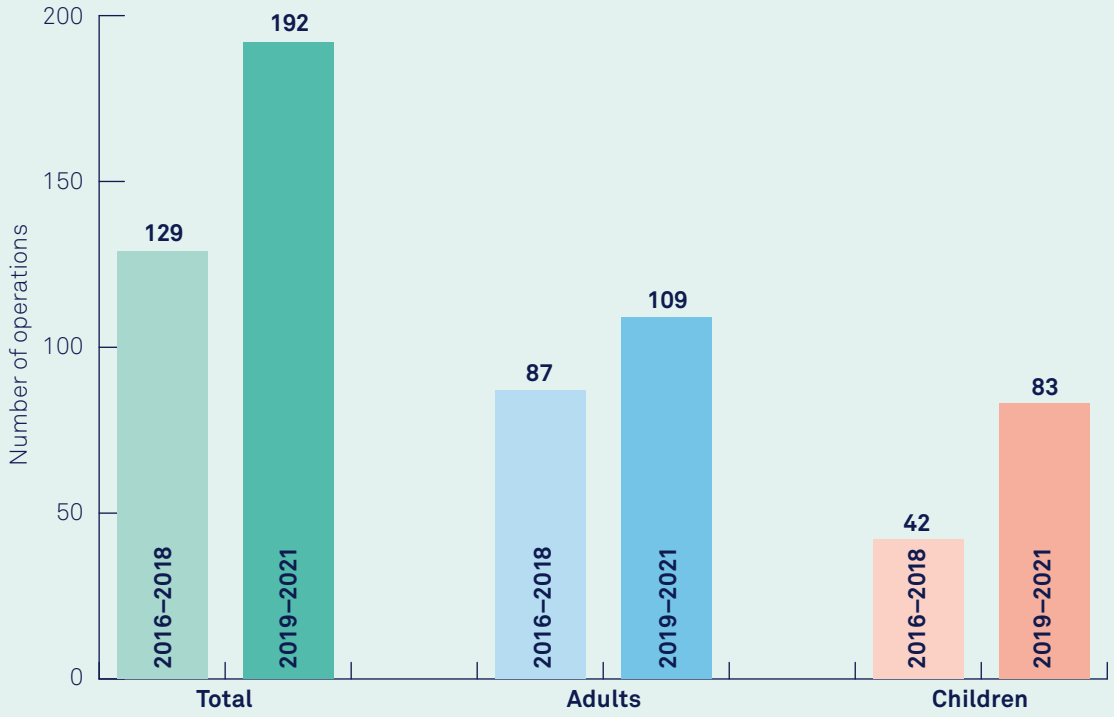
The most common procedures represent resections of epileptogenic foci, such as low-grade tumors (LEATS), or focal dysplasias (n = 52, 27 %), on the one hand, and temporal resections for temporal lobe epilepsy (n = 45, 23 %), on the other. Additionally, the Department of Neurosurgery specializes in invasive cerebral epilepsy assessment. A total of 30 (16 %) electrode implantations were carried out as part of an invasive epilepsy assessment procedure, in order to provide suitable assessment and treatment to patients with complex forms of the disease. In 28 patients (14 %) with drug-resistant epilepsy, a vagus nerve stimulator was implanted to treat the condition.
The scientific focus of the Working Group is on improving epilepsy surgery techniques to increase postoperative seizure freedom. On the one hand, this allowed us to describe the rates of seizure freedom in long-term follow-up in one of the largest cohorts of patients on whom selective amygdalahippocampectomy was performed.

We were also able to present the microsurgical anatomy and the procedure of perithalamic hemispherectomy – a procedure that, to date, can only be offered in Austria at our clinic. Another aspect of epilepsy surgery is the planning and placement of electrodes for invasive EEG monitoring.
In a collaborative project with the working group headed by Prof. John Duncan (National Hospital for Neurology and Neurosurgery – University College London Hospitals) already existing advantages but also possibilities for improvement of semi-automated planning software for the implantation of depth electrodes have been explored.

Our group was instrumental in gathering various basic research findings, such as the distribution of GABA receptors in the amygdala and hippocampus.
Similarly, the ability to divert signals directly from the cortex during neurosurgical procedures has allowed important electrophysiological data to be collected that could potentially redefine resection margins. A major objective is to come up with an answer to the contentious question surrounding the significance of the intraoperative electrocorticogram in modern neurosurgery. Future projects designed to get to the bottom of this particular question and to develop more effective methods of detecting the epileptogenic zone are also currently being planned.

Epilepsy surgery		2019	2020	2021	Total	%
Total operations		63	62	67	192	100 %
Adults		36	35	38	109	57 %
Children		27	27	29	83	43 %
Total	Electrode implantation	5	16	9	30	16 %
	AMTLR/SAHE/ATLR	19	10	16	45	23 %
	Lesionectomy/resection	22	15	15	52	27 %
	Disconnection	3	2	3	8	4 %
	Callosotomy	2	8	1	11	6 %
	Hemispherectomy	4	3	2	9	5 %
	Vagus nerve stimulator surgery	8	8	12	28	14 %
	LITT	–	–	9	9	5 %
Adults	Electrode implantation	2	8	1	11	–
	AMTLR/SAHE/ALTR	14	10	13	37	–
	Lesionectomy/resection	9	6	9	24	–
	Disconnection	2	0	0	2	–
	Callosotomy	1	3	0	4	–
	Hemispherectomy	0	0	0	0	–
	Vagus nerve stimulator surgery	8	8	12	28	–
	LITT	–	–	3	3	–
Children	Electrode implantation	3	8	8	19	–
	AMTLR/SAHE/ALTR	5	0	3	8	–
	Lesionectomy/resection	13	9	6	28	–
	Disconnection	1	2	3	6	–
	Callosotomy	1	5	1	7	–
	Hemispherectomy	4	3	2	9	–
	Vagus nerve stimulator surgery	0	0	0	0	–
	LITT	–	–	6	6	–

Number of epilepsy surgery operations 2016–2021

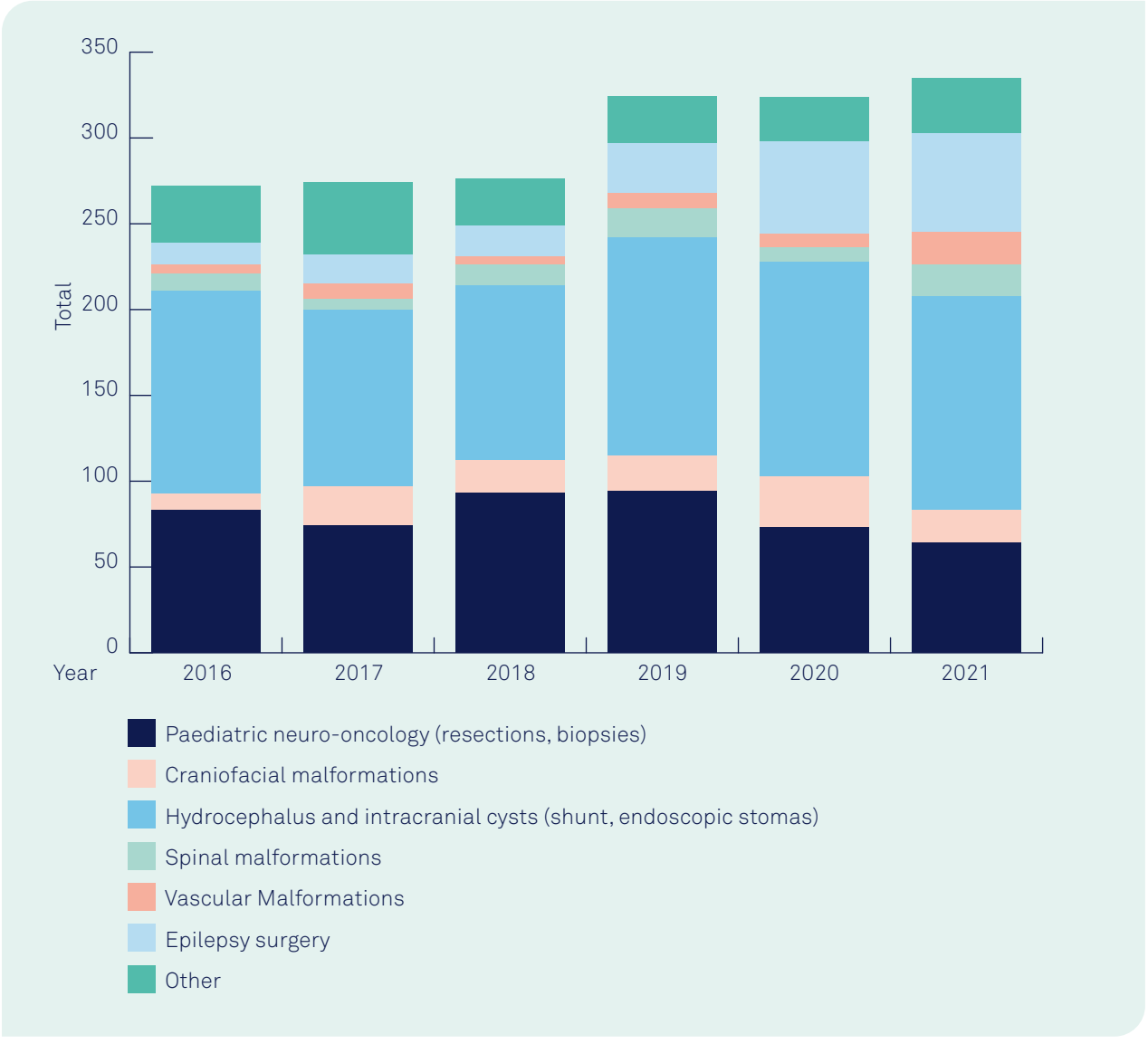


Neuropaediatric Working Group

Paediatric Neurosurgery: minimally invasive endoscopy and microsurgery for tissue restoration for children and infants

Headed by: Andrea Reinprecht, Christian Dorfer
Deputy: Johannes Herta

Neuropaediatric operations performed in our Department between 2016 and 2021.



Paediatric neuro-oncology
Effective interdisciplinary cooperation between the Departments of Neurosurgery, of Pediatric and Adolescent Medicine, of Biomedical Imaging and Image-guided Therapy, of Anaesthesia, Intensive Care and Pain Medicine and the Department of Radiation Oncology forms the foundations for paediatric neuro-oncology and ensures optimal care for our young patients.

Preoperative planning and intraoperative techniques
New and innovative imaging techniques are continuously applied in close cooperation with the Division of Neuroradiology and Musculoskeletal Radiology to enhance the effectiveness of preoperative diagnostics and preoperative planning. These structural and functional imaging techniques include functional MR, resting-state fMR, fibre tract imaging using DTI, and also MR spectroscopy. The data obtained using these techniques can be applied directly in the operating theatre with the aid of intraoperatively applied neuronavigation for to support the surgical intervention.

Alongside imaging, intraoperative neurophysiological monitoring is another important technique for monitoring neurological functions in functionally critical tumour localisation (spinal cord, brain stem, central region).

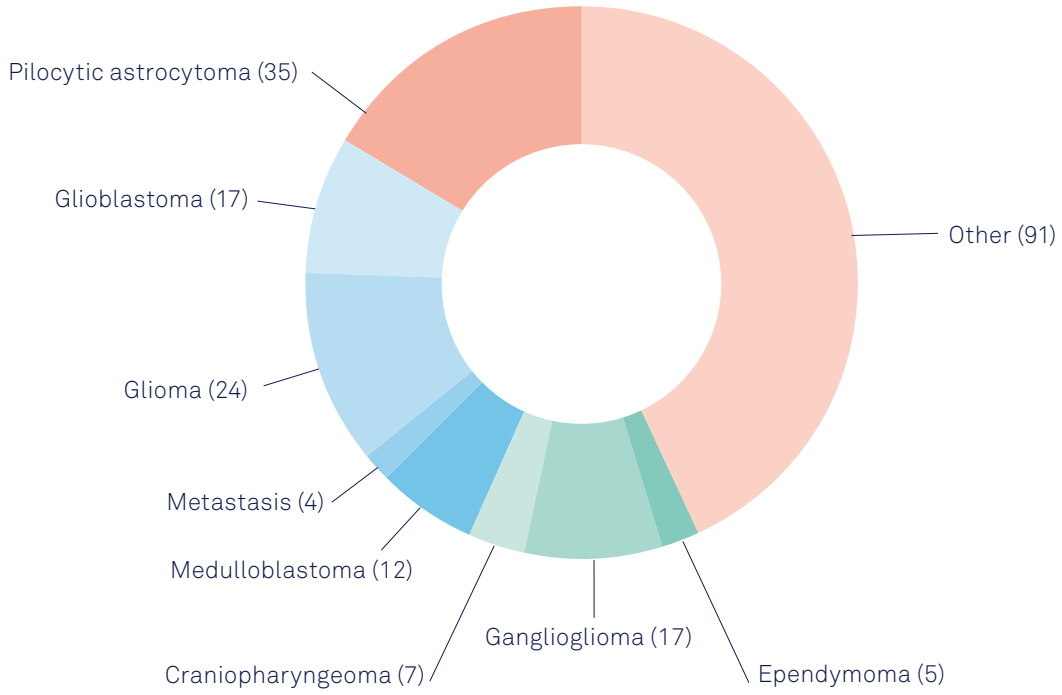
Postoperative observation
Monitoring directly after treatment takes place either in the Paediatric Intensive Care Unit (PICU, Department of Pediatrics and Adolescent Medicine) or in the Intermediate Care Unit at the Pediatric Surgery Centre (Department of Anesthesia, Intensive Care Medicine and Pain Medicine). Afterwards, the young patients are cared for on the paediatric oncology ward (Level 9, Department of Pediatric and Adolescent Medicine). Each case is discussed within the interdisciplinary Pediatric Tumour Board (p. 71) and world-class individually tailored therapy plans are implemented in line with international study protocols.

International therapy studies
Thomas Czech is a reference neurosurgeon and coresponsible for the neurosurgical protocol guidelines in both the completed SIOP LGG* 2003 and the upcoming SIOP LGG 2014 European therapy study for low-grade CNS tumours (Low Grade Glioma).

Thomas Czech is the reference neurosurgeon as well for the SIOP CNS GCT** II therapy study for the treatment of intracranial germ cell tumours (ICGCTs). He has also chaired the SIOP-BT Working Group for ICGCTs since 2013. The Department of Neurosurgery is playing a significant part in the current SIOP study for the treatment of ependymomas. Christian Dorfer and Thomas Czech are members of various SIOP working groups, in which new study protocols are being developed.

* International Society of Pediatric Oncology – Low Grade Glioma
** International Society of Pediatric Oncology – Central Nervous System Germ Cell Tumour

Childhood brain tumours: total OPs 2019–2021



Craniofacial malformations

In recent decades, cranial growth abnormalities caused by craniosynostosis have been diagnosed with increasing frequency. As a result, the number of outpatient presentations involving patients with craniosynostosis is increasing, as is the number of surgical interventions. The surgical procedures for these patients are carried out in close cooperation with the Department of Pediatrics and Adolescent Medicine, the Department of Anesthesia, Critical Care and Pain Medicine and the Department of Oral, Maxillary and Facial Surgery. More than half of the surgeries involved children with sagittal suture synostosis, which is the most common form of craniosynostosis. About 45 % of these cases were treated by a vertex craniectomy performed before the patient reached the age of three months. The other children were on average eight months old at the time of the operation.

Interventions in the fronto-orbital region – in the case of unilateral or bilateral coronary suture synostosis or of trigonocephalus with synostosis of the Sutura Metopica – are performed as an interdisciplinary procedure that also involves oral and maxillofacial surgery. Genetic alterations occur in about 10–20 %, with bilateral coronal suture synostosis being the most common craniosynostosis that occurs as part of a syndrome and has a much higher recurrence rate than other non-syndromal forms. The most common syndromes associated with craniosynostosis diagnosed in recent years were Apert, Crouzon, Muenke, Pfeiffer and Turner syndromes. These children are assessed and cared for in cooperation with the Department of Pediatrics and Adolescent Medicine and the Institute of Medical Genetics.

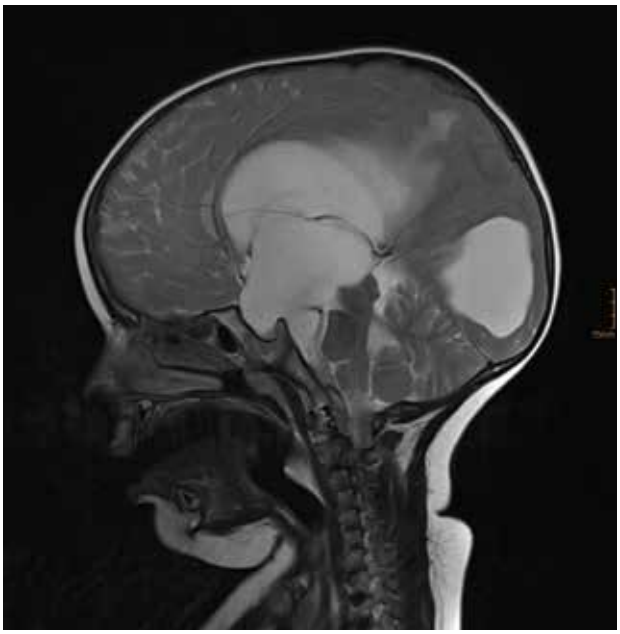
Both initial presentation and further care of patients with suspected or diagnosed craniosynostoses take place in a specialist weekly outpatient clinic, where assessment and further neurosurgical care as well as interdisciplinary assessment can be carried out.

Hydrocephalus, interacranial cysts and neuroendoscopy

In modern neurosurgery, neuroendoscopy is now established both as an independent method and as a complementary method to microsurgery, as it enables minimally invasive treatment of various neurosurgical diseases. Used in combination with electromagnetic neuronavigation, endoscopes specially developed for children allow intracranial cysts or complex forms of hydrocephalus to be operated on even in premature and newborn babies.

As well as being a good alternative to shunt surgery for forms of occlusive hydrocephalus in children, endoscopic III ventriculostomy can be considered thanks to its success rate the first choice therapy also in this age group. Endoscopic ventriculostomies, even in very young children aged 2 weeks to 2 years, allowed normalisation of CSF flow in more than 75 % of cases, without the need for implantation of a shunt system. Endoscopic septostomies and other intraventricular fenestrations, in conjunction with a shunt system, have been used in the treatment of complex forms of post-haemorrhagic hydrocephalus with isolated portions of the ventricular system in premature infants with very or extremely low birth weights.

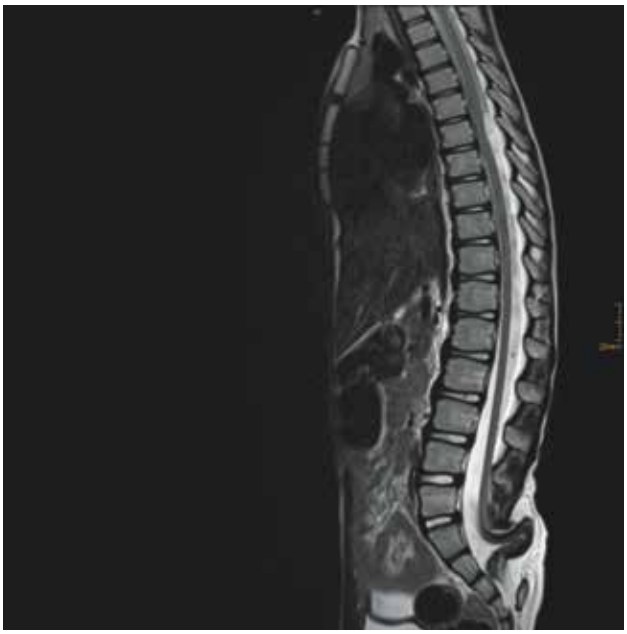
Intraventricular and paraventricular cysts in children have been successfully treated by a single endoscopic fenestration at the age of just a few days.



MRI imaging of congenital hydrocephalus

Dysraphia and spinal malformations

While open dysraphisms are now rare in newborns in Europe due to advances in prenatal medicine, it is largely patients with closed spinal dysraphisms who benefit from effective interdisciplinary care, and their neurosurgical treatment is further optimized by systematic use of complete intraoperative neurophysiological monitoring.In recent years, mainly children but also adults with different forms of covered dysraphism have been operated on: the spectrum includes lypomyeloceles, meningoceles, dermal sinuses, diastematomyelia, tight filum terminale syndrome and forms of caudal regression syndrome. Microsurgical intervention techniques in combination with intraoperative neurophysiology can ensure the best possible solution for the spinal cord while delivering the greatest possible level of patient safety. Both perioperative and long-term care of these patients is interdisciplinary, involving neuropaediatricians, paediatric urologists and paediatric orthopaedic specialists. Regular joint discussions take place in the Dysraphy Board (p. 71).



MRI image of lumbar myelomeningocele

International cooperation partners::

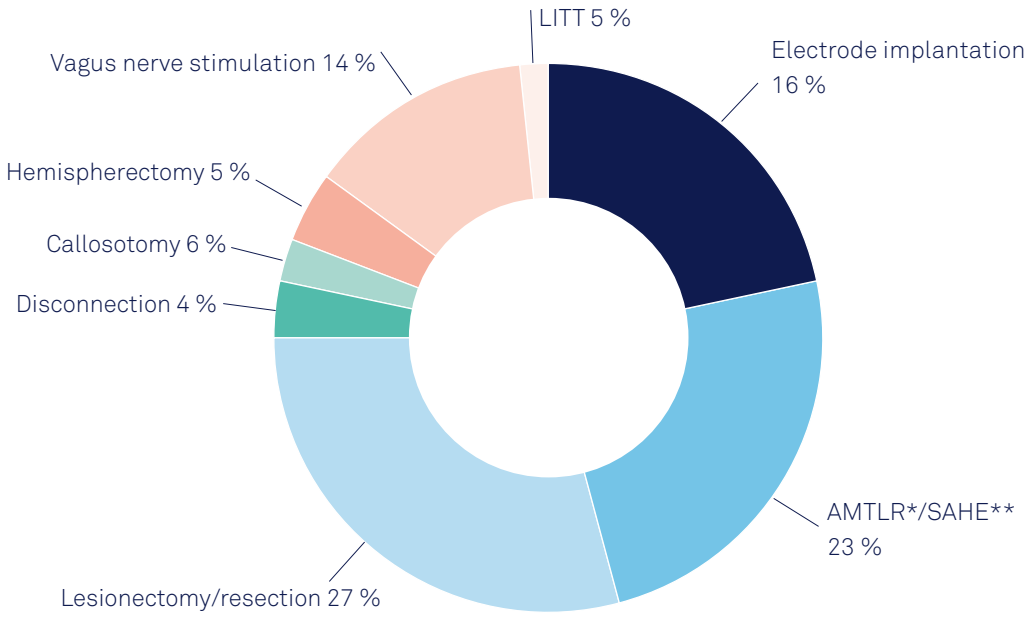
- Harvard Medical School, Department of Pediatric Oncology, Dana-Farber Boston Children's Cancer and Blood Disorders Center, Boston, USA
- University of California, Los Angeles, Mattel Children's Hospital and Ronald Reagan UCLA Medical Center, Los Angeles, USA
- University of Toronto, Department of Surgery, Division of Pediatric Neurosurgery, The Hospital for Sick Children, Toronto, Canada

Photos: Neuroradiology

Vascular malformations
The treatment of vascular malformations in children follows a similar pattern to that for adults after discussion in the Vascular Board (see p.70). Microsurgery, endovascular procedures and Gamma Knife radiosurgery are used either alone or in combination, as decided on a case-by-case basis.

Paediatric epilepsy surgery
An epilepsy surgery programme including the paediatric age group was established at University Hospital Vienna between 1993 and 1995. Since 2005, children have been cared for and assessed at the Epilepsy Monitoring Unit at the Department of Paediatrics and Adolescent Medicine. The centre at University Hospital Vienna is a reference centre for children with drug-resistant epilepsy. Since 2019, our epilepsy centre has been the only one in Austria to be recognised as a reference centre for epilepsies (ERN EpiCare) within the framework of the European Reference Network for rare and low prevalence complex diseases – ERN. Therapeutic procedures in epilepsy surgery include hemispherectomies, multilobar disconnections, focal resections with intraoperative electrocorticography and, if necessary, callosotomies and vagus nerve stimulator implantations. In Austria, many of these procedures are only available at our Department of Neurosurgery. Subdural and/or depth electrodes are implanted for invasive chronic monitoring, depending on the case.

Operations 2019–2021 by type of operation



*AMTLR: anteromedial temporal lobe resection
**SAHE: selective amygdalohippocampectomy

Photo: Vadi Fuoco/Shutterstock.com >

Skull Base Surgery and Neurotraumatology Working Group

Skull base surgery: Complex microsurgery on the supporting pillars of the brain

Headed by: Christian Matula
Deputy: Matthias Millesi

The Department of Neurosurgery has a long tradition of skull base surgery.
Over the years, the Department has become firmly established as a nationally and internationally renowned centre for skull base surgery. In the course of its ongoing development, modern, forward-looking techniques have been implemented in clinical routine over time, including endoscopic skull base surgery, multimodal image-guided neuronavigation and intraoperative MRI, as well as other pioneering surgical techniques and methods such as piezosurgery, cryosurgery and neurophysiological intraoperative monitoring.

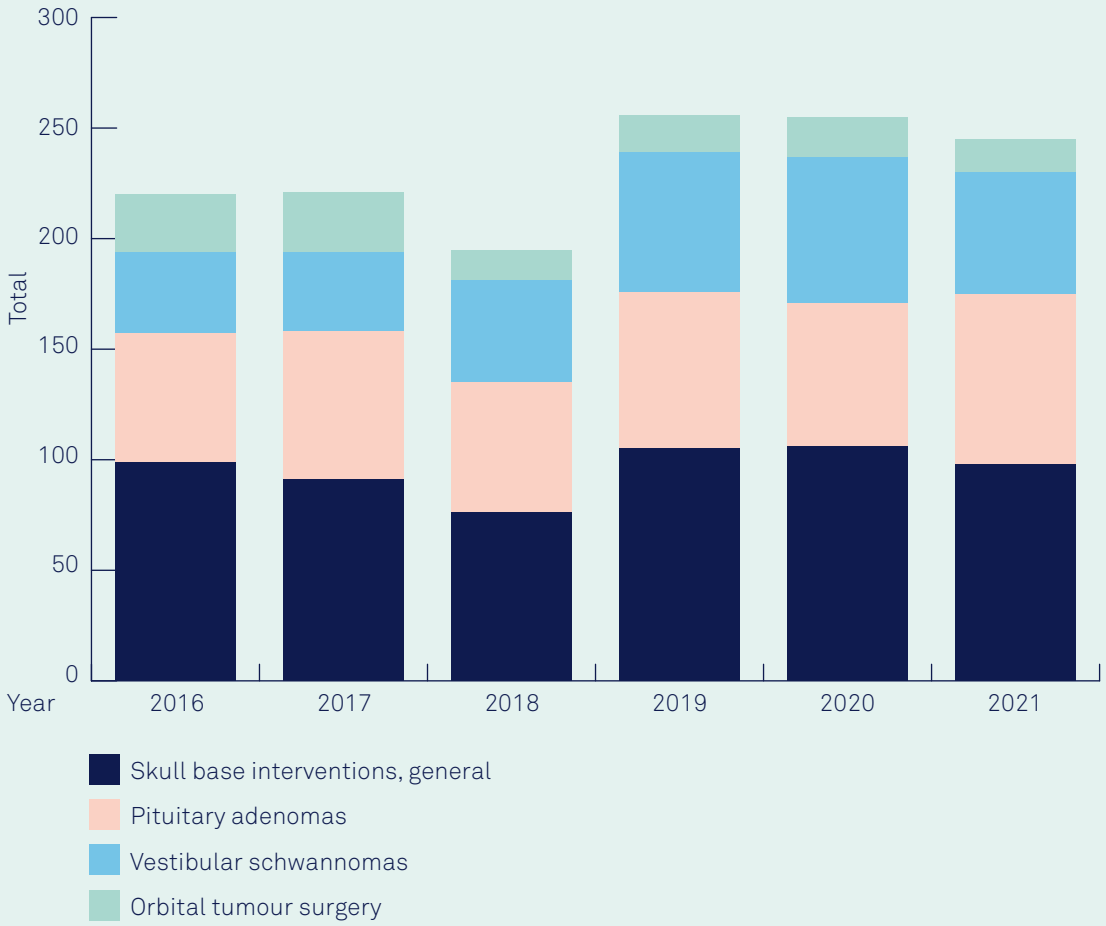
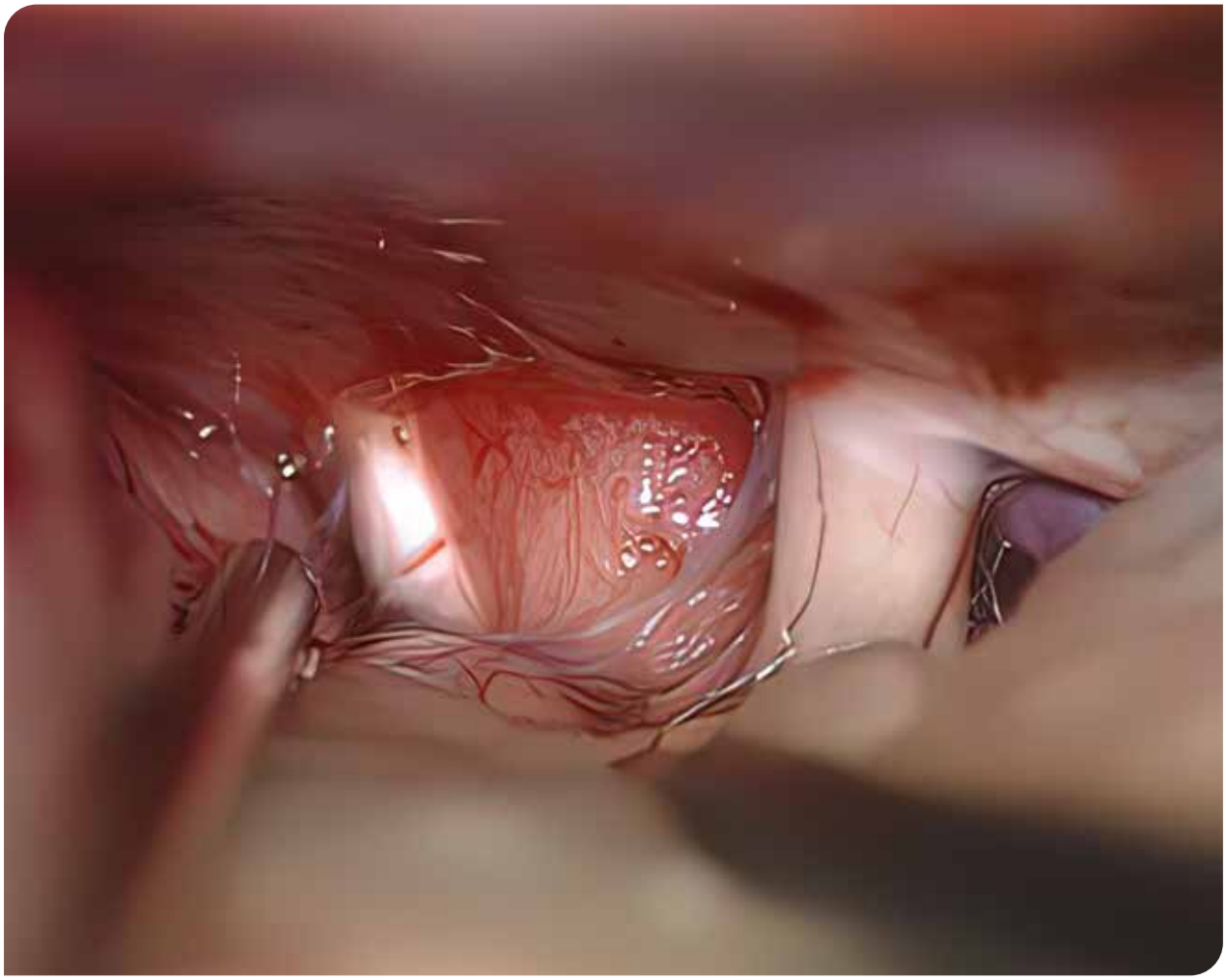


Photo: Wei-Te Wang

Clinical routines in skull base surgery

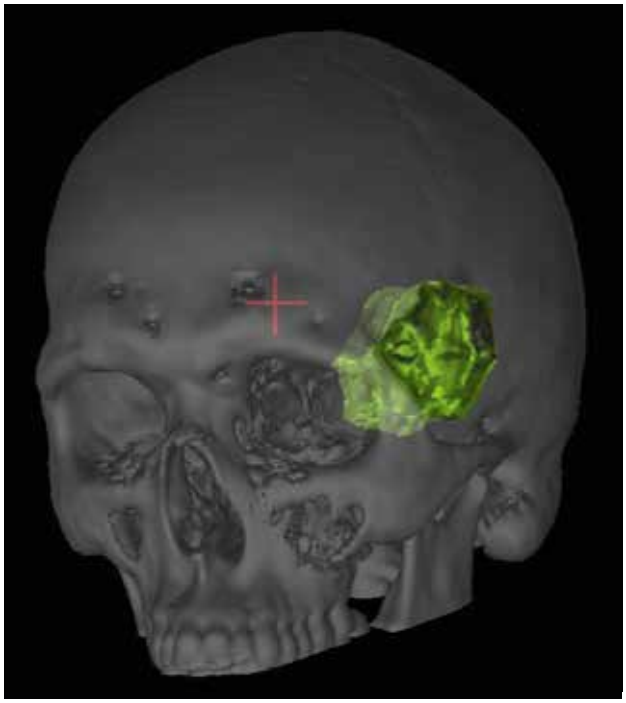
Microsurgical and endoscopic procedures at the base of the skull represent about 20 % of all surgical skull operations. The entire skull base is covered, including the craniocervical transition with interventions in the facial area (transfacial) for example through the mouth (transoral), the nose and paranasal sinuses (transnasal, transmaxillary, etc.) and the eye cavity (transorbital), the anterior cranial fossa (anterior fossa and, through it, transbasal), the middle cranial fossa (middle fossa), the central cranial base (in the sellar/perisellar space), the posterior cranial fossa (posterior fossa, including the temporal bone, transpetrosal) up to the craniocervical transition (far lateral approaches, transcervical, etc.). The approaches used range from "simple" standardised skull base access (subfrontal, laterobasal, pterional, subtemporal, retrosigmoidal, etc.) and their various modifications to highly complex combined – often also multi-cavity (e.g. transglabial, transbasal) – procedures (e.g. orbito-zygomatic variants, combined supra/infratentorial intervention, far lateral transcervical or transjugular).

The cases treated range across all age groups (from newborn to old age, oldest case 92 years), include all pathology areas (vascular, tumor, trauma, reconstruction) and concern mostly benign diseases (about ⅔ cases), more rarely also malignant (about ⅓ of the cases).



Intraoperative visualisation of a vestibular schwannoma between the cranial nerves stretched over it

Photo: Neurosurgery



Visualisation of the localisation of a brain tumour by fusion of MRI and CT images in the neuronavigation system

Photo: Neurosurgery

* The AO Foundation is a non-profit educational, innovation and research organisation led by a global network of surgeons.

Research and teaching in skull base surgery

Starting in 2018, over the past few years members of the Skull Base Surgery Working Group have been invited to give around 30 lectures around the world. Team members also led and conducted nine courses with integrated hands-on practice and international as well as multidisciplinary participation, in addition to holding around 20 training and continuing education courses.

Skull base courses

Entitled "Practical cadaver hands-on and training on live tissue", the first neuroendoscopy training course took place in 2008 under the auspices of the newly created Vienna Neuroendoscopy Working Group. It was conducted in the experimental operating theatres in the main building at University Hospital Vienna. In addition, the first International Interdisciplinary Skull Base Course took place in Vienna in a collaboration with the AO* Foundation. Attracting strong interest from international participants, other courses followed. Thanks to the generous support of the AO Foundation, AONeuro was established as an independent division within the AO Foundation in 2014. Special thanks go to Professor Paul Manson, formerly of the Mayo Clinic, now of Johns Hopkins Hospital, Baltimore, USA, former AO President and now Chair of the AO Board of Directors. Due to his tireless support, we were able to ensure that the AONeuro Skull Base courses and AO Neurotrauma courses will take place in Vienna for the next few years.

Current projects (selected)

- **Tumours and other space-occupying lesions of the orbit and their treatment.**
  In cooperation with the Departments and Divisions of Ophthalmology, Radiology, Ear-Nose-Throat Diseases, Oncology, Radio-Oncology, Gamma Knife, MedAustron-Centre for ion beam therapy and research.
- **Hearing analysis and reconstruction as well as biological molecular analysis after surgery on vestibular schwannomas.**
  In cooperation with the Departments and Divisions of Radiology, Ear-Nose-Throat Diseases, Oncology, Gamma Knife.
- **Trauma of the skull base**
  In cooperation with the Departments and Divisions of Trauma-Surgery, Anaesthesia, Radiology.

Vision for the future

The major vision for the future is to improve and optimise functions, an undertaking that reflects the flourishing, decades-long partnership between the Department of Neurosurgery and the Department of Otorhinolaryngology. Examples of this include the ongoing interdisciplinary project – "Intraoperative implants to improve the hearing situation after removal of vestibular schwannomas", and another ongoing interdisciplinary project – "Bringing molecular analysis of brain tumours into common clinical practice: Establishing the Austrian Neuro-Oncology (ANN) brain tumour tissue bank", this time as part of an international cooperation involving the Skull Base Surgery Working Group.

Neurotraumatology

Headed by: Christian Matula
Deputy: Matthias Millesi

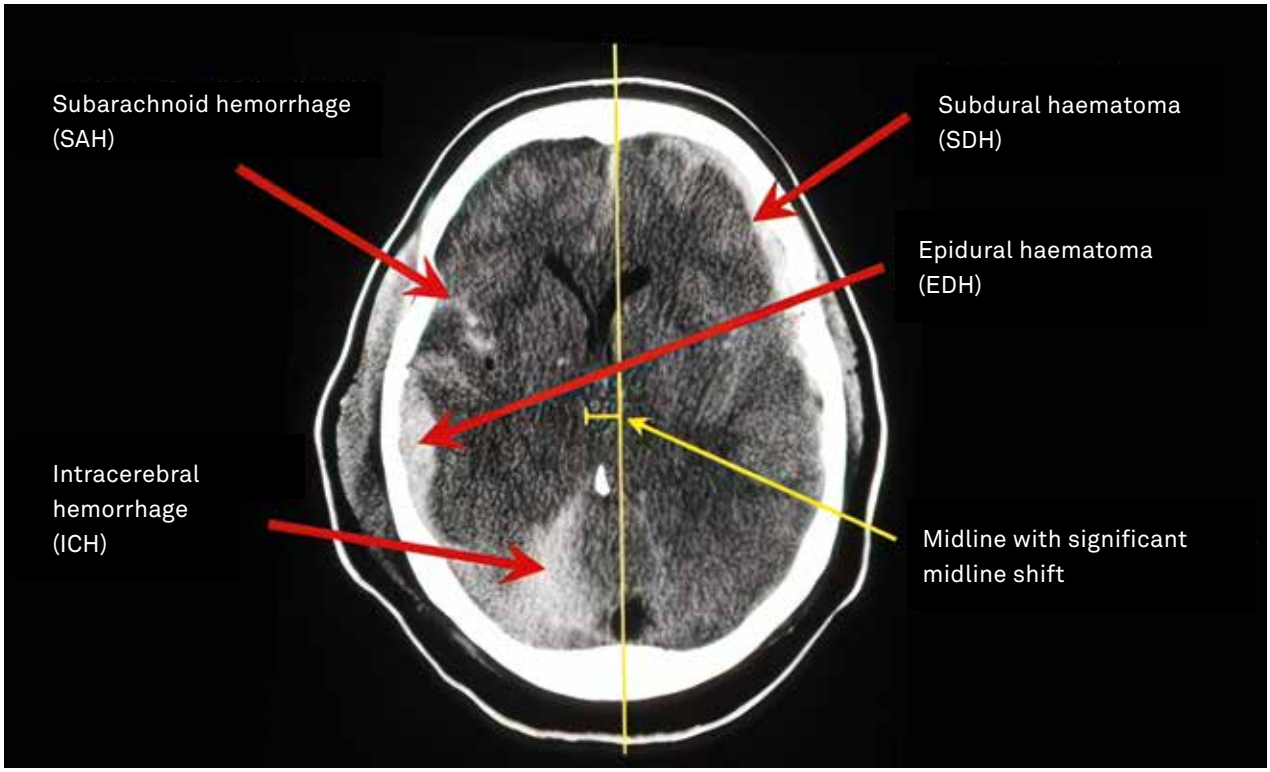
The provision of care for patients with craniocerebral traumas and patients with spinal column traumas involving the spinal cord or cauda is a core neurosurgical competence and, accordingly, represents an integral part of the Department's clinical and scientific activities.

Over the past 50 years, it is not just surgical modalities for the treatment of patients with traumatic brain injury (TBI) that have changed – other non-surgical treatment options have emerged as insights have grown and technologies have improved, particularly in the field of neurointensive care.

Advances in research have driven a paradigm shift in knowledge of the physiology of healthy and injured brains. Understanding of intracranial pressure reduction through mass removal has been complemented by awareness of the role of ischaemia in the context of the so-called secondary injury.

Neurotraumatology at the Department of Neurosurgery
Neurotraumatological procedures account for around 12–15 % of all the Department's surgical services. Indications include classic trauma-related haemorrhages such as intracerebral haemorrhage, epidural haematomas and subdural haematomas (acute, subacute, chronic). We also treat fractures of the skullcap (calvarium) and skull base (frontobasal covers), posttraumatic disorders of the cerebrospinal fluid circulation (hydrocephalus), vascular injuries to the skull and post-traumatic calvarium reconstructions.

Interdisciplinary neurotrauma management
Especially in recent years, the Department of Neurosurgery has intensified its cooperation with the Department of Trauma Surgery. Neurosurgical colleagues are regularly called to the shock room when on duty and involved in decision-making processes. Surgical treatment in acute situations is usually carried out jointly in the operating theatres of the Department of Trauma Surgery. This cooperation also extends to postoperative care and any subsequent aftercare.

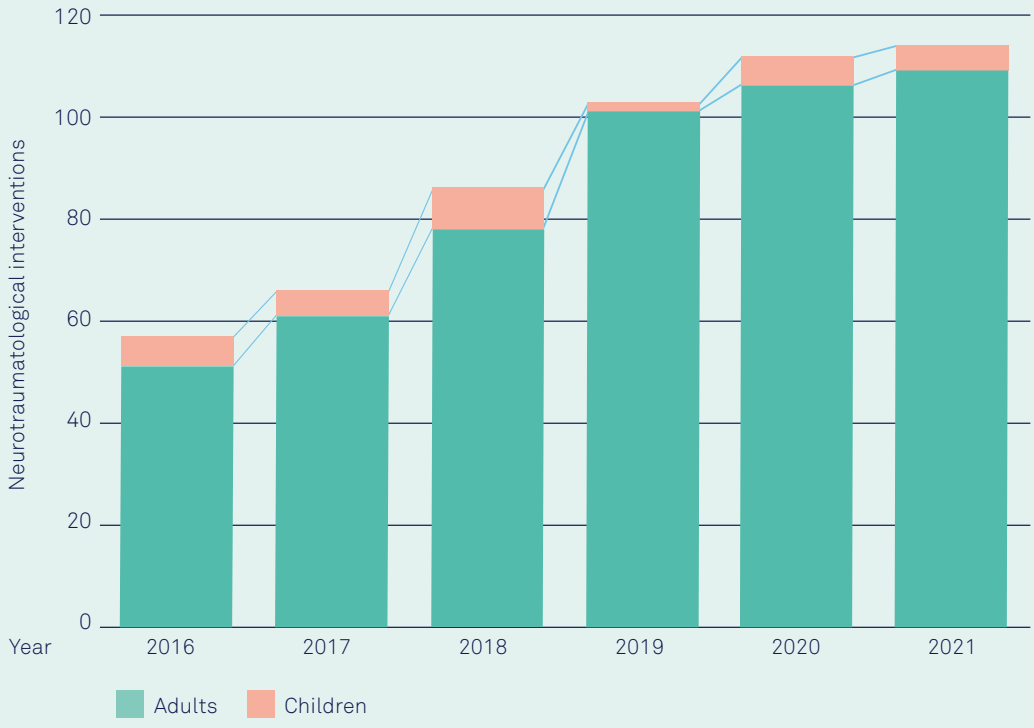


Typical chronic subdural haematoma with acute haemorrhage, mirror formation and midline shift

Chronic subdural haematoma with midline shift

Photos: Neuroradiology

Neurotraumatology services 2016–2021



Spinal Working Group

Spinal neurosurgery: Microsurgery to treat paraplegia

Headed by: Walter Saringer
Deputy: Magnus Kueß

The Department of Neurosurgery has played a significant part in improving treatment outcomes for patients with spinal disorders. New techniques for surgery on the cervical spine have been developed and established, proven interventions clinically evaluated, methodologies improved and new implants tested and introduced.

Degenerative diseases of the spine
All forms of degenerative diseases of the spine are treated surgically:

- Herniated discs
- Spinal stenosis
- Foraminal stenosis
- Arnold-Chiari malformations
- Pseudospondylolisthesis

Treatment of degenerative diseases at the Department of Neurosurgery is largely focused on the area of the cervical spine.
In recent years, several types of **intervertebral disc prostheses** for the cervical spine have been tested. An easy-to-implant, diamantine-coated, biologically inert prosthesis currently in use is showing good long-term results.

Herniated discs	Lumbar	273
	Cervical	104
	Thoracic	2
Spinal stenosis		71
Arnold-Chiari malformations		13
Synovial cysts		22
Total		**485**

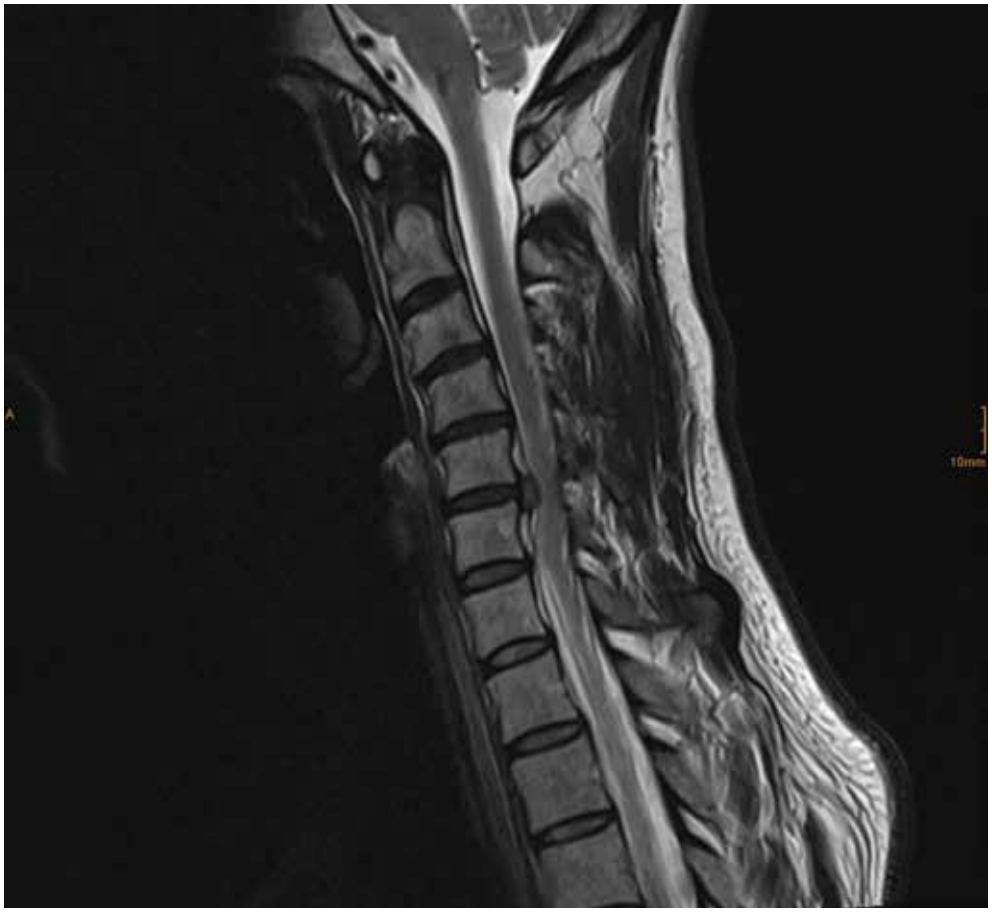


Photo: Neuroradiology

MRI of a cervical disc herniation at level C5/6 with compression of the spinal cord

Development of new surgical methods
Walter Saringer has developed a new surgical method for the cervical spine and implemented it at the Department of Neurosurgery: **microsurgical and endoscopic ventral foraminotomy,** which is used to treat foraminal stenosis and herniated discs. The advantage of this method over conventional surgical alternatives is that it is a minimally invasive approach and opens up the possibility of operating on several segments of the spine at the same time and avoids fusions. Besides preserving the mobility of the operated segments, it also prevents diseases of the connecting segments, i.e. premature degeneration of the adjacent segments.

Fabian Winter, assistant physician at the Department, is currently involved in two research projects in collaboration with the Department of Spine Surgery at the Hospital for Special Surgery in New York City:
- Incidental Durotomy during Lumbar Spine Procedures and
- A Prospective Multivariate Analysis for Incidental Durotomy Risk Factors during Lumbar Spine Surgery.

Tumours of the spine
All extradural, intradural and intramedullary tumours are treated surgically, either microsurgically or endoscopically.

The most common are:
- Neurinomas
- Ependymomas
- Meningiomas
- Gliomas

Intraoperative neurophysiological monitoring is routinely used during surgery to monitor neurological functions in functionally critical tumour localisations.

Tumours	Neurinomas	34
	Meningiomas	21
	Ependymomas	16
	Metastases	6
	Chordoma	4
	Lipomas	3
	Haemangioblastoma	3
	Other	13
Total		**100**

Photo: Neuroradiology

MRI of an intraspinal, intradural neurinoma at the level of the L2 vertebrae

Gamma Knife Radiosurgery Working Group

Gamma Knife radiosurgery: Cutting into the brain with a radiation knife

Clinical Director: Brigitte Gatterbauer
Scientific Director: Josa Frischer
Medical Physicist: Andreas Ertl

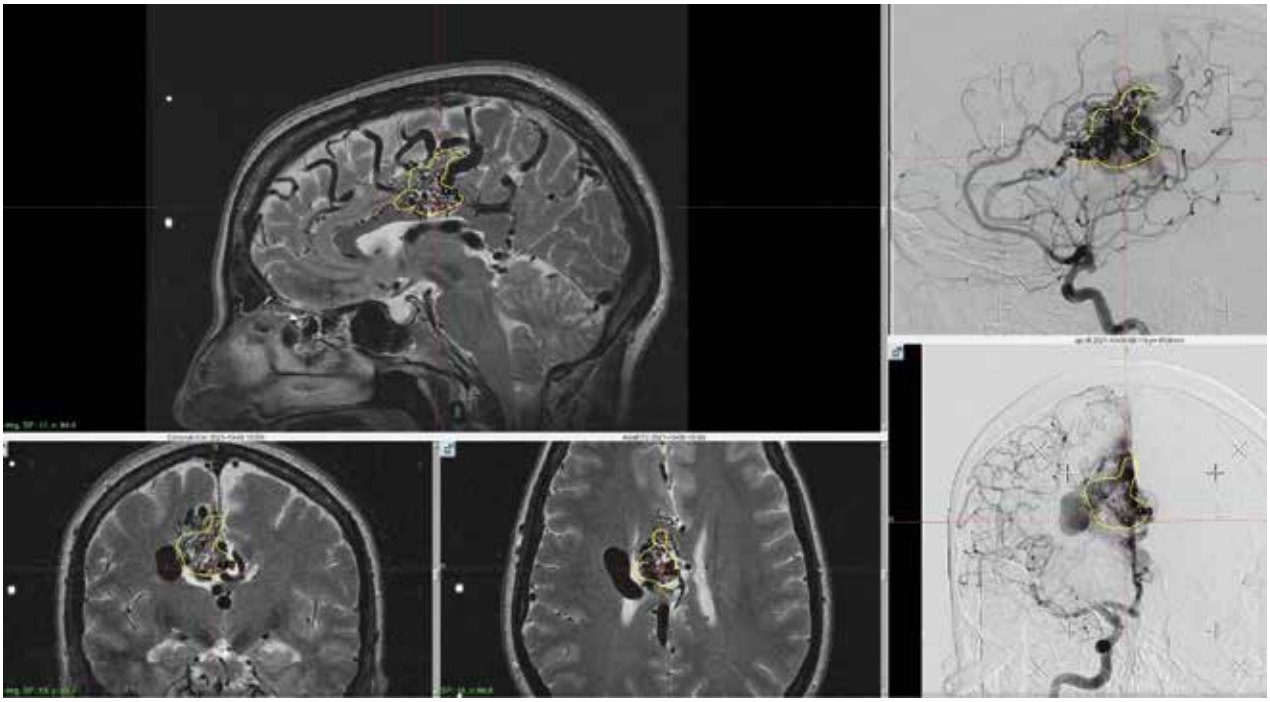
Clinical services 2019–2021

The Department of Neurosurgery at the Medical University of Vienna operates Austria's only Gamma Knife. In the past 28 years, around 10,000 patients have already been treated using radiosurgery. The modern radiosurgical era began at the Department of Neurosurgery with the installation of the Perfexion® Gamma Knife in June 2012. In Gamma Knife radiosurgery, cerebral lesions are irradiated at high doses under stereotactic conditions. In the Perfexion® Gamma Knife, 192 cobalt sources are arranged in a ring, which is divided into eight sectors and focused on the centre with a very high degree of accuracy. The area to be irradiated is adapted to the lesion to be treated with the help of different-sized collimators. A state-of-the art neurosurgical tool, Gamma Knife radiosurgery can be used either as the main therapy or in combination with other treatment approaches.

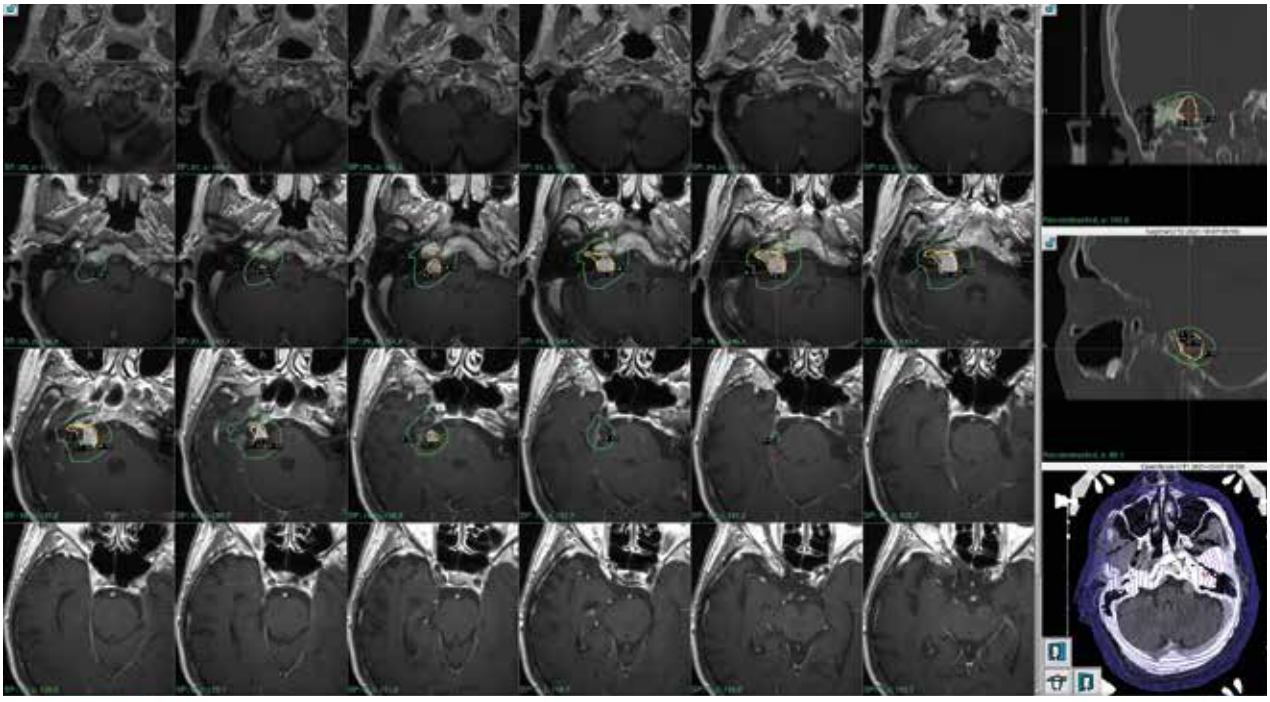
The most common indications include brain metastases, cerebral vascular malformations and benign tumours such as meningiomas and vestibular schwannomas, with functional radiosurgery forming another focus. Due to the high, precisely applied dose and the steep fall-off in the dose, multiple lesions, such as multiple brain metastases, can also be treated in a single procedure.

New developments in recent years, especially in the field of immunotherapy and personalised oncological medicine, pose new challenges for radiosurgery, too. At the same time, however, research is uncovering new approaches that are already being implemented in the scientific Radiosurgery Working Group.

Photo: Neurosurgery



Gamma Knife planning for the treatment of an arterio-venous malformation



Gamma Knife planning for the treatment of a vestibular schwannoma

Photos: Neurosurgery/Neuroradiology

Gamma Knife treatment procedure

Indications, patient information and appointments are made at the Department's Gamma Knife Outpatient Clinic. Patients are admitted the day before their Gamma Knife treatment. Before the radiation process is initiated the next day, the stereotactic frame must first be attached to the patient's head.

To do this, the fixation sites are anaesthetised using a local anaesthesic which is administered subcutaneously. Next, the stereotactic frame is secured with four screws and remains in position until after the procedure is completed.

After the frame has been put in place, a planning examination is performed, usually an MRI with contrast medium, or CCT.

Radiosurgical interventions	**2019**	**2020**	**2021**
Metastases	329	352	345
Vascular deformities	10	7	23
Meningiomas	35	23	58
AKN/schwannomas	35	30	39
Pituitary adenomas	5	7	5
Other	6	12	15
Total/year	**420**	**431**	**485**

Research and teaching

The Gamma Knife Radiosurgery Working Group at the Department of Neurosurgery is headed by Josa Frischer. It is a very active group – in terms of both research and teaching – that includes PhD students, diploma students and research assistants.

As illustrated in the numerous publications to its credit, special emphasis is placed on cooperation within our Department, but also at an interdisciplinary level. Collaboration with the Department of Neurosurgery's Vascular Working Group and interdisciplinary collaboration with the Departments and Divisions of Neuroradiology, Neurology, Oncology and Dermatology all being cases in point.

Collaborative research activities are also ongoing with the Karl Landsteiner Institute of Lung Research and Pulmonary Oncology at Floridsdorf Hospital, the Department of Pulmonology/Oncology at Penzing Hospital, the Department of Pulmonology/Oncology at Ottakring Hospital and the Obninsk Gamma Clinic in Russia.

Publication highlight of 2019

Evaluation of the radiosurgical treatment of cerebral arteriovenous malformations: a retrospective single-centre analysis of three decades

Dorian Hirschmann, Philipp Goebl, Frederic H Witte, Brigitte Gatterbauer, Wei-Te Wang, Philippe Dodier, Gerhard Bavinzski, Adolf Ertl, Wolfgang Marik, Ammar Mallouhi, Thomas Roetzer, Christian Dorfer, Wilhelm Eisner, Andreas Gruber, Klaus Kitz, Josa M Frischer.

Journal of Neurointerventional Surgery, 12(4), 401–406. Epub 2019 Sept 26.

This study analysed 516 patients with cerebral arterio-venous malformations (AVM) who were treated using Gamma Knife radiosurgery between 1992 and 2018.
It showed that both radiosurgical treatment on its own and combined radiosurgical-endovascular treatment are effective and safe options for cerebral AVMs. The time to occlusion and the occlusion rate were mainly influenced by the volume of the AVM and the Spetzler-Ponce class. While the median time to occlusion was 3.8 years in patients treated with radiosurgery alone, this rose to 6.5 years in patients who received a combined treatment of Gamma Knife and endovascular embolisation. However, prior embolisation before Gamma Knife treatment resulted in a significant reduction in median time to nidus occlusion and a higher occlusion rate in selected higher-grade AVMs.

Neurosurgical Intensive Care Medicine

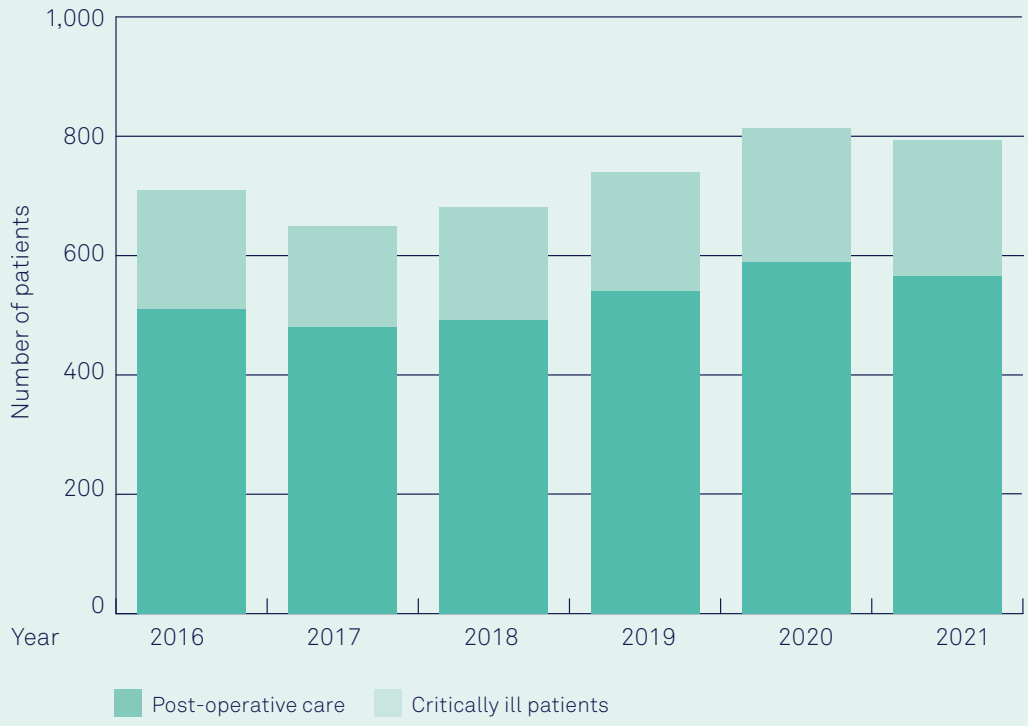
Headed by: Andrea Reinprecht
Deputy: Johannes Herta

The Department of Neurosurgery's intensive care unit opened in 1984 when the Department moved to the new Neurosurgery building. For more than 30 years, it has provided primary care for neurosurgical cerebral and spinal diseases, as well as postoperative monitoring of patients following neurosurgical interventions. Run in close cooperation with the Department of Anaesthesia, Intensive Care and Pain Medicine, it was officially recognised by the Austrian Medical Association as a training centre for the neurosurgery subspecialty field "Neurosurgical Intensive Care Medicine" on 1 July 2010 in accordance with section 11 para. 1 of the 1998 Ärztegesetz (Physicians Act).

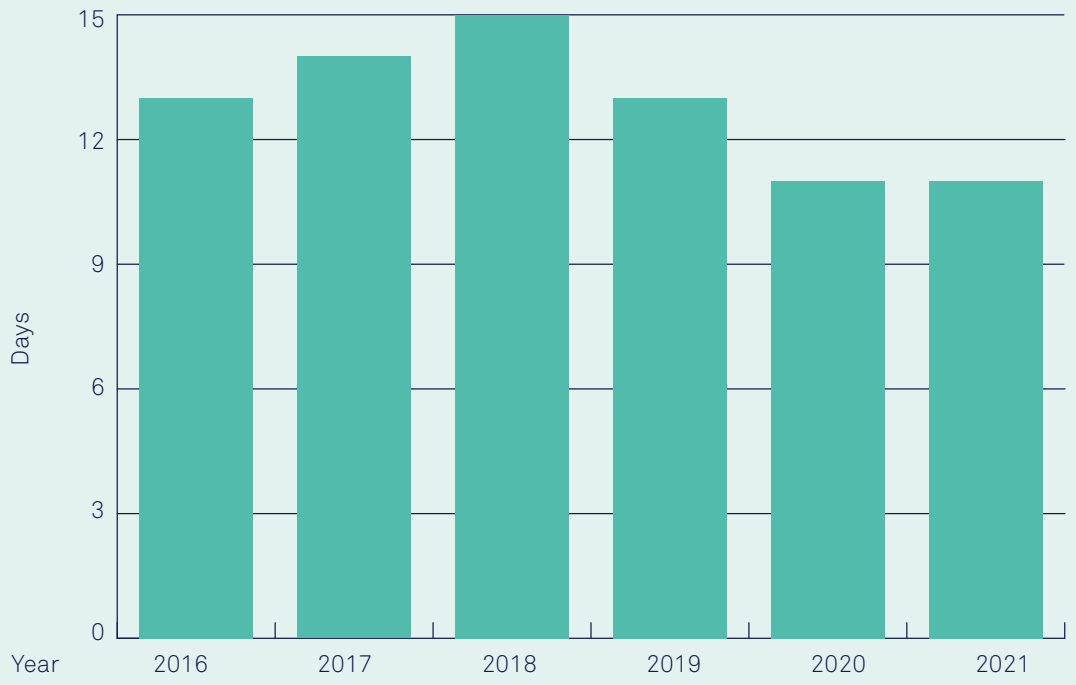
Due to the ward's special designation and extensive experience in the interdisciplinary treatment of neurosurgical conditions, it has become a key training centre also for nursing staff and doctors from a range of disciplines. According to the specific task, practically all procedures used in the treatment of cerebral and extracerebral organ dysfunctions are available.

As part of the current development plan of MedUni Vienna, intensive care medicine – and within this Invasive Neuromonitoring – has been declared one of the decided development priorities. With implementation of comprehensive multimodal neuromonitoring including conventional intracranial pressure measurement, cerebral oxygen partial pressure measurement and cerebral microdialysis complete, the full scope of these monitoring procedures is now available.

Case numbers, neurosurgical ICU



Average length of stay (days) of critically ill patients



Multimodal neuromonitoring

Neurosurgical intensive care medicine relies on highly developed monitoring procedures for early detection of secondary cerebral ischaemia. For patients with severe cerebral haemorrhages, monitoring of cerebral oxygen partial pressure and metabolism as well as the continuous EEG are standard at our unit – in addition to continuous intracranial pressure measurement. This kind of multimodal neuromonitoring not only enables early detection and, as a result, treatment of secondary ischaemia, but also allows a tailored adaptation of the individually applied therapies.

Despite huge advances in intensive care medicine, neurological outcome of many patients with subarachnoid haemorrhages remains poor. Hemorrhage-induced neuroinflammation, impairment of the coagulation cascade and severe cerebral vasoconstriction often lead to severe ischaemic deficits just days after the initial bleeding event. We recently reported that an endogenous increase in arterial blood pressure was observed in patients with subarachnoid haemorrhage due to the induced cerebral blood loss (Hosmann et al, 2020).

Besides using drugs to raise arterial blood pressure, pharmacological vascular dilatation by means of endovascular procedures can also be used to treat cerebral vasospasm. Given the contentiousness of these neuro-interventional techniques, we went on to review the effects on vessel diameter and the occurrence of cerebral insults in a retrospective analysis (Hosmann et al, 2018). During the review, we observed that endovascular therapies only had a very limited effect in preventing the occurrence of cerebral infarction. As a result, a prospective study was initiated to investigate the influence of intra-arterial papaverine hydrochloride on brain metabolism and oxygenation using multimodal neuromonitoring. We were only able to observe a short-term improvement in cerebral metabolism in a few patients, and such change only occurred for a few hours after the intervention (Hosmann et al, 2020). These findings led to the use of nimodipine for intra-arterial spasmolysis at our Department.

As part of our routine monitoring, cerebral microdialysis allows the unbound concentration of drugs behind the blood-brain barrier to be determined. For antibiotics in particular, determining concentrations at the site of action is extremely important for their effectiveness.

The cerebrospinal fluid(CSF)-permeable antibiotic Cefuroxime is routinely used in our Department for perioperative prophylaxis. Analysis of the pharmacokinetics measured using cerebral microdialysis determined that just one third of the concentration measured in the plasma actually reaches the brain parenchyma (Hosmann et al, 2018). Determination of the cerebral pharmacokinetics of other antibiotics is currently under investigation.

Non-convulsive seizures occur very frequently in critically ill patients and are a highly underdiagnosed and underestimated phenomenon, especially in the comatose group. As the duration of non-convulsive seizures is associated with a greatly increased mortality rate, seizures need to be detected and treated early. This requires monitoring by means of continuous electroencephalography (EEG), which was primarily introduced at our intensive care unit in 2013 as part of a project funded by the Austrian Research Promotion Agency (FFG) with 1.66 million euros. In this project, a computer-based analysis tool for long-term EEGs was developed in partnership with the Austrian Institute of Technology (AIT) and evaluated at our clinic (Herta et al, 2015, 2017). In 2016 and 2018, we were twice awarded the Herbert Reisner Prize of the Austrian Society of Epileptology for our work.

Research into multimodal neuromonitoring in recent years has led to a wide acceptance of the sometimes complex examinations by nursing and medical staff. As a result, we are now one of the few neurosurgical intensive care units in the world that covers the entire range of cerebral monitoring techniques, which allows us to offer individualised multimodal neuromonitoring to patients with acute cerebral diseases.

Pituitary Adenoma Working Group

Headed by: Christian Matula
Deputy: Matthias Millesi

Innovations in surgical technology
In 2002, endoscopic pituitary surgery was introduced at the Department of Neurosurgery at MedUni Vienna and University Hospital Vienna, almost completely replacing the previous microscopy technique. Since then, our neurosurgeons have performed more than 700 procedures purely endoscopically, transnasally and transsphenoidally. The initial mononostril approaches have been supplemented by binostril and "extended" approaches.

Thanks to these advances (both in terms of instrumentation and increasing experience of endoscopic surgical techniques), it is now possible to operate safely and efficiently on lesions in difficult-to-reach areas of the skull base using what are referred to as "extended approaches". In particular, pathologies in the skull-base midline region – frontobasal, supradiaphragmatic and clival – can be reached endoscopically through the nose.

Innovations in visualisation
Endoscopic imaging has also improved significantly since 2002. A high-resolution 3D HD endoscope has been available since 2019, which eliminates the previous disadvantage of endoscopy – namely the exclusively two-dimensional view – improves orientation and is designed to make endoscopic interventions even safer.
A further improvement was achieved through the enhancement of imaging in cooperation with the Department of Biomedical Imaging and Image-guided Therapy's Division of Neuroradiology and Musculoskeletal Radiology: Thanks to the MR pituitary protocol, special high-resolution image sequences are now available for intraoperative neuronavigation during endoscopic transsphenoidal procedures.

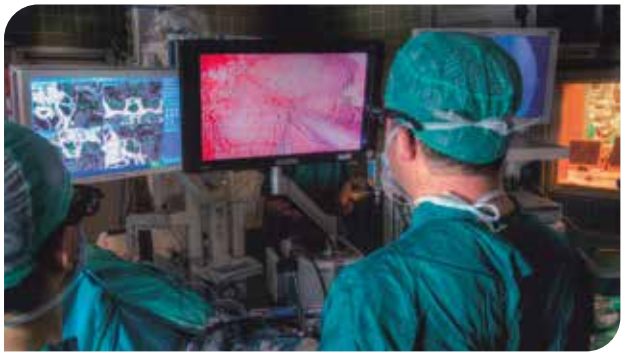


Photo: Stefan Wolfsberger

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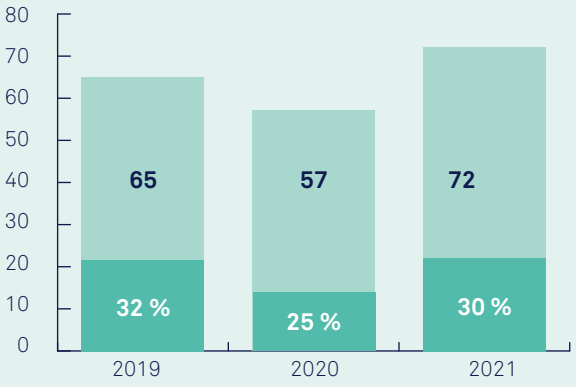


Remission rates for functional pituitary adenomas:

	PRL	GH	ACTH	Mixed PRL/GH	Pluri	TSH
Microadenomas	82 %	75 %	91 %	100 %	86 %	–
Macroadenomas	58 %	48 %	55 %	33 %	75 %	67 %

Functional Neurosurgery, Pain and Intraoperative Neurophysiology Working Group

Headed by: Klaus Novak
Deputy: Johannes Herta, Wei-Te Wang

The Functional Neurosurgery, Pain and Intraoperative Neurophysiology Working Group deals with a variety of neurosurgical procedures used to treat functional disorders of the nervous system such as movement and gait disorders, cognitive dysfunction, epileptic seizures, pain syndromes and psychiatric disorders. Members of the Working Group are also involved in the supervision of intraoperative neurophysiological examinations (Intraoperative Neuromonitoring, IOM).

The underlying principle of the treatments is the use – where possible – of a non-destructive modulation of nervous system functions in order to cure conditions, alleviate symptoms or slow the progression of disease-related impairments. Patient treatment is based on broad interdisciplinary cooperation with the Departments of Neurology, Pediatrics and Adolescent Medicine, Biomedical Imaging and Image-guided Therapy, Psychiatry and Psychotherapy as well as anaesthesia, general intensive care medicine and pain therapy.

Working Group news and projects

Movement disorders

The cooperation with the Department of Neurology was stepped up in 2019 with the re-organisation and expansion of the Movement Disorders Group headed by Christof Brücke (formerly of the Charité hospital, Berlin). The new appointment brings on board an expert from one of the leading European centres for research into the pathophysiology of the basal ganglia and the treatment of movement disorders. Close interdisciplinary cooperation starts at the complex preoperative assessment stage and extends to the diagnosis and selection of patients for deep brain stimulation (DBS), intraoperative neurophysiological testing and perioperative therapy adjustment for patients being treated using DBS. As a result, a total of 40 deep brain stimulations were performed from 2019 to 2021, in spite of the drop in the number of elective procedures carried out due to the pandemic. Our future projects in this area include:

- Changing over target planning to a 3T MRI system, for which a new metal-free stereotaxic frame system (Vantage™ Frame, [Fig. 1]) is also planned.
- In a further step, there are plans to extend the planning software to include Diffusion Tension Imaging (DTI) data sets from MRI planning and use of the Brainlab planning system.
- In partnership with the Department of Neurology, the Working Group is evaluating the conditions for changing and modernising the intraoperative microelectrode recording system.
- Advances in stimulation system technologies with segmented stimulation electrodes (Fig. 2a and 2b) and the registration of local field potentials via the stimulation electrodes (Fig. 3a and 3b) will help us to adapt therapies even more closely to the individual requirements of patients with specific movement disorders.

Figure 1: Metal-free stereotactic frame system with aiming arm for implantation of electrodes for deep brain stimulation (Leksell® Vantage™ Stereotaxy System)

Figure 2a

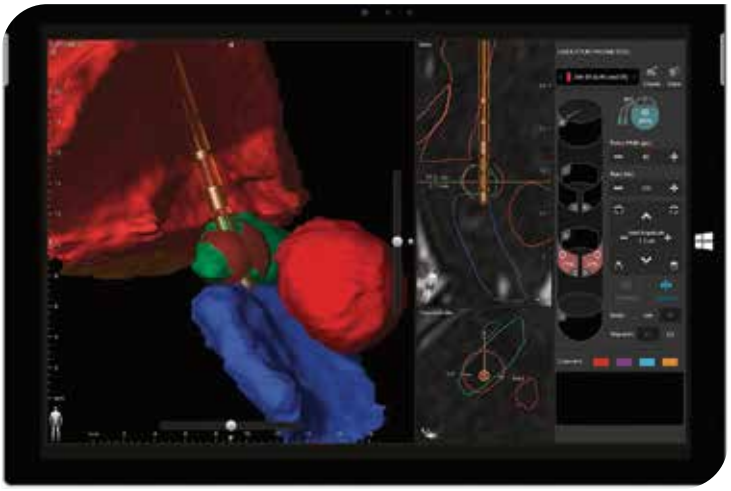


Figure 2b

Photos: Boston Scientific

Figs. 2a and 2b: The tip of a segmented DBS electrode with eight contacts (Vercise Cartesia™). The ability to control individual contacts allows for customised configuration of stimulation fields through directional stimulation after testing the effect and side effects of the treatment.

Figure 3a

Figure 3b

Photos: Medtronic

Figure 3a: A new generation of neurostimulators (Percept™ PC) has software that makes it possible to record electrical potentials from the implanted stimulation electrode. The changes in the frequency spectrums (Figure 3b) correlate with the symptoms of Parkinson's disease and could provide valuable information to adjust the stimulation parameters for individual Parkinson's patients.

Currently, thalamus lesion surgeries (thalamotomies) can be performed bloodlessly using the Gamma Knife in patients with tremor disorders for whom deep brain stimulation is not an option. The Department of Neurosurgery at MedUni Vienna and University Hospital Vienna has the only device in Austria that is suitable for this type of therapy

A pioneering ultrasound-based procedure that does not require radioactive radiation has been available for the treatment of essential tremor since 2016 (FDA approval in 2016, CE mark in 2018).
Although technically complex, the procedure – carried out in the MRI machine – is more gentle on the patient. Together with the Departments of Neurology and Biomedical Imaging and Image-guided Therapy, we are working on establishing the logistical, physical and economic conditions for the introduction of Austria's first magnetic resonance imaging-guided focused ultrasound therapy (MRgFUS) for performing targeted US lesions in the brain. Using this groundbreaking method, the target region in the thalamus can be heated by focused ultrasound energy. The patient remains awake during the procedure and is cognitively monitored until the tremor symptoms disappear.

Epilepsy
The Medical University of Vienna's Departments of Neurology and Neurosurgery decided early on to use DBS in the treatment of pharmacoresistant epilepsy as part of the interdisciplinary project – "Pre-surgical clarification and epilepsy surgery". In 2011, the first patient in Austria was treated with DBS, through chronic stimulation of the nucleus anterior thalami. Since then, eight patients have been operated on and included in an ongoing study of long-term outcomes as part of a multicentre European registry (Medtronic Registry for Epilepsy, MORE).
Vagus nerve stimulation (VNS) has been successfully used since 1999 in the treatment of therapy-resistant epilepsies for which curative surgical intervention is not possible. See also Epilepsy Surgery Working Group (page 24).

Psychiatric diseases
The non-destructive character of surgical techniques applied in functional neurosurgery makes it possible to use surgical intervention, under strict indication, even in severe therapy-resistant psychiatric diseases. In light of this insight, two vagus nerve stimulators designed to treat severe depression were implanted for the first time in Austria in 2020 by Karl Rössler. Patients were enrolled in a multicentre study (RESTORE-LIFE), conducted jointly with the Department of Psychiatry and Psychotherapy to evaluate the effectiveness of the therapy in the treatment of severe depression.
Similarly, patients with severe obsessive-compulsive disorders are being recruited for treatment with DBS. In a monocentric study (Glucose metabolism under deep brain stimulation in obsessive-compulsive disorder) conducted jointly with the Department of Psychiatry and Psychotherapy and the Department of Biomedical Imaging and Image-guided Therapy, a special protocol can be used at the Medical University of Vienna to determine the effects of the therapy by measuring sugar metabolism in the brain using functional positron emission tomography (fPET).

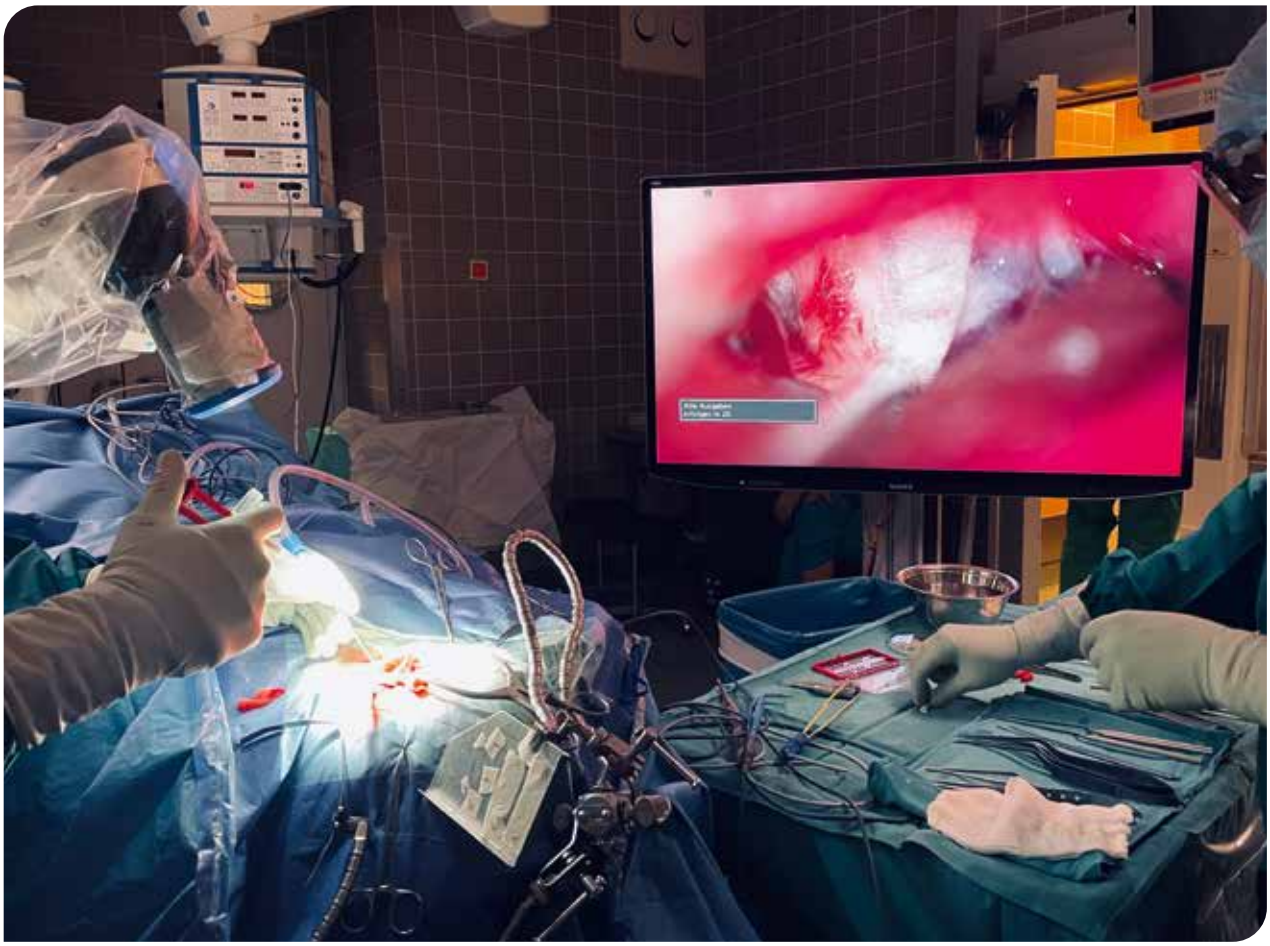
Normal pressure hydrocephalus
In the treatment of normal pressure hydrocephalus, we have developed an assessment protocol in cooperation with the Department of Neurology (Outpatient Clinic for Movement Disorders and Outpatient Clinic for Memory Disorders and Dementia), which includes radiological and nuclear medicine examinations and can improve the prognosis for the neurosurgical therapy by implantation of a ventriculoperitoneal shunt system.

Pain: Trigeminal neuralgia

The treatment of trigeminal neuralgia is an important element of functional neurosurgery at the Medical University of Vienna. Working in close consultation with our partner departments (Department of Neurology and Department of Anesthesia, Critical Care and Pain Medicine), we indicate the appropriate surgical therapy for patients if an attempt at conservative therapy has been unsuccessful. In addition to the standard surgical procedure of microvascular decompression (Jannetta method), we are able to offer patients a variety of alternative procedures if necessary. Ablative procedures such as thermocoagulation and balloon compression of the anglion gasseri or Gamma Knife treatment of the trigeminal nerve are among the options. Minor procedures such as Botox and glycerol injections or ganglionic local opioid applications, which can be performed on an outpatient basis, are also offered.

Number of surgical interventions for trigeminal neuralgia 2019–2021

Operative Eingriffe	2019	2020	2021
Thermocoagulation	13	13	11
Balloon compression	7	2	5
Microvascular decompression	9	10	10
Total	**29**	**25**	**26**



Microvascular decompression (Jannetta method) for trigeminal neuralgia

Photo: Johannes Herta

Intraoperative Neuromonitoring (IONM)

Intraoperative Neuromonitoring is an integral part of neurosurgical operation planning. Through its potential to detect and predict neurological deficits intra-operatively at an early stage, it has helped to expand the surgical indications for high-risk operations and reduce permanent neurological deficits to a minimum.
The Department of Neurosurgery is one of the first institutions in Europe to establish routine intraoperative diagnostics using motor evoked potentials from muscle as well as from the spinal cord, and monitoring of corticobular motor evoked potentials (motor cranial nerve monitoring).
In the field of intraoperative Neuromonitoring, we have performed around 200 operations with IONM annually thanks to the support of two staff members with additional training in this specialised field.

Biomedical analyst: Sandra Cestar Stefan Reitbauer

Photo: Wei-Te Wang

Navigation, Simulation and Robotics Working Group

Headed by: Christian Dorfer, Karl Rössler
Deputy: Fabian Winter

Navigation

Combining structural, functional and metabolic image data to create a procedure-specific multimodal image is one of the main focuses of the Working Group's Neuronavigation team. Thus, specific image fusion protocols for glioma-, skull base- and pituitary surgery have already been developed, published, and continuously used.
At the annual DTI Tractography international workshop, held for the 12th time at the Department of Neurosurgery in 2019, the fibre tract architecture of the brain was illustrated using a unique combination of anatomical preparation and electronic imaging. Multimodal image fusion concepts, especially for glioma surgery, were also presented.

The existing multimodal fusion protocol for transnasal pituitary surgery was extended to include a special CT surface representation of the endonasal anatomy, which has made it possible to clearly identify the finest structures (e.g. thin septations). MR angiographic imaging has also been improved to specifically identify fine vessels (e.g. sphenopalatine artery). This protocol is intended to enhance the safety of endoscopic transsphenoidal procedures. For skull base surgery, a special navigation protocol was developed using the example of sphenoorbital meningiomas in order to remove soft tumour parts as well as tumor-altered bones to the fullest extent possible while protecting neurovascular structures. In 2019, two additional BrainLab navigation systems became available, complementing the existing pair of Medtronic navigation systems.

Photos: MedUni Vienna/Christian Houdek

Photo: MedUni Wien/Christian Houdek

Simulation

There are currently four workstations available for preoperative procedure planning based on 3D simulation of the patient's individual anatomy. A simulator for practicing neurosurgical skills in a 3D environment that also gives haptic feedback is available. Used for training and student teaching, it was developed in cooperation with the National Research Council Canada.
At the microsurgical laboratory, facilities for the three-dimensional representation of anatomy are now also available for training and teaching: in addition to a surgical microscope with 3D video recording capability, a robotic photo camera has been developed that enables automated recording of 3D images.

Robotics

Since 2012, the Department of Neurosurgery has been using a miniaturised robot system which was developed in Austria for stereotactic interventions (e.g. biopsies, deep electrode implantations) as part of a feasibility and development study. This robot system is the first device to deliver the advantages of high positioning accuracy (≤ 0.1mm) while taking into account the limited space available in the operating theatre. It was shown that the robot does not influence operating theatre routines thanks to its miniaturised design and compatibility with the existing navigation system, meaning that it does not prolong the duration of the operation either.
The prototype of the robotic system was tested in multicentre trials (Vienna, London, Milan) and fine-tuned at the Department of Neurosurgery at MedUni Vienna and University Hospital Vienna. An instrument and drilling system was implemented that allows for more precise and minimally invasive biopsies compared to conventional procedures.
As of 2019, the robot has been approved for stereotactic biopsies, implantation of depth electrodes for stereoEEG and laser ablation.

Advances in robot-navigated laser craniotomy for implantation of depth electrodes in epilepsy surgery

Over the past two years, we have been working closely with Advanced Osteotomy Tools, a Swiss medical robotics company, to expand the applications for a laser which has already been certified in oral and maxillofacial surgery to include neurosurgical operations. Specifically, the aim of the peer-reviewed studies published so far was to optimise the implantation of depth electrodes in epilepsy surgery. Tested for the first time in a cadaver (Rössler et al. Robotic Navigated Laser Craniotomy for Depth Electrode Implantation in Epilepsy Surgery: a cadaver lab study. Journal of Neurological Surgery 2020) the frameless stereotactic method using robotic laser ablation achieved target point accuracies of 2.0mm (+/0.64SD) for frontal, parietal and occipital trajectories for depth electrodes planned using preoperative CT data sets. The time for implantation was 10–15 minutes per electrode, and just under a minute for laser ablation.

These results were subsequently confirmed in several in-vivo non-recovery studies in pigs (Winter et al. Navigated, Robot-Driven Laser Craniotomy for SEEG Application Using Optical Coherence Tomography in an Animal Model. Frontiers in Robotics and AI. 2021). It should also be mentioned that there were no anaesthesiological problems during the operations and the animals all survived the laser ablations. The results of the first in-vivo recovery study on sheep at MedUni Vienna still require further analysis and evaluation before the first pilot studies can be conducted on humans. However, the conclusion so far is that navigated robot-assisted laser craniotomies for the implantation of depth electrodes represent a promising new alternative to conventional frameless hand-guided craniotomies.

Molecular and Intraoperative Imaging Working Group

Molecular imaging: Ultra-strog magnetic fields for research into brain tumour biology

Headed by: Gilbert Hangel
Clinical Supervisor: Karl Rössler
Team: Barbara Kiesel, Fabian Winter, Gudrun Mayr-Geisl, Cornelius Cadrien, Philip Lazen, Sukrit Sharma

For many years, the Departments of Neurosurgery and of Biomedical Imaging and Image-guided Therapy have been cooperating in treatment planning and in various research projects. One milestone is the joint research into pathologies on the High Field MR Centre's 7 Tesla scanner.

Under one such example, state-of-the-art metabolic imaging based on high-resolution MRSI has been tested in gliomas in partnership with Georg Widhalm since 2014. The latest milestone achieved is the start of operations using the intraoperative MRI scanner (Siemens Skyra) on level 8, which is operated by the Departments of Neurosurgery and the Division of Neuroradiology and Muskuloskeletal Radiology.

First intraoperative MRI on level 8 of the Department of Neurosurgery

Photo: Neurosurgery

Ongoing studies of 7T-MRSI in tumours (including the "3D 2HG mapping as biomarker for IDH-mutation in glioma" project, which is funded by the Austrian Science Fund) also continued successfully in 2020, despite operational restrictions triggered by the pandemic.
A total of 70 patients (gliomas, lymphomas, meningiomas) have been measured so far using a world-leading 3D MRSI sequence with 3.4mm isotropic resolution and the corresponding values have been measured and analyzed. The first results for high-grade gliomas were published in Neuroimage: Clinical in September 2020.
A more in-depth statistical evaluation of the results gathered so far is planned in the near future.

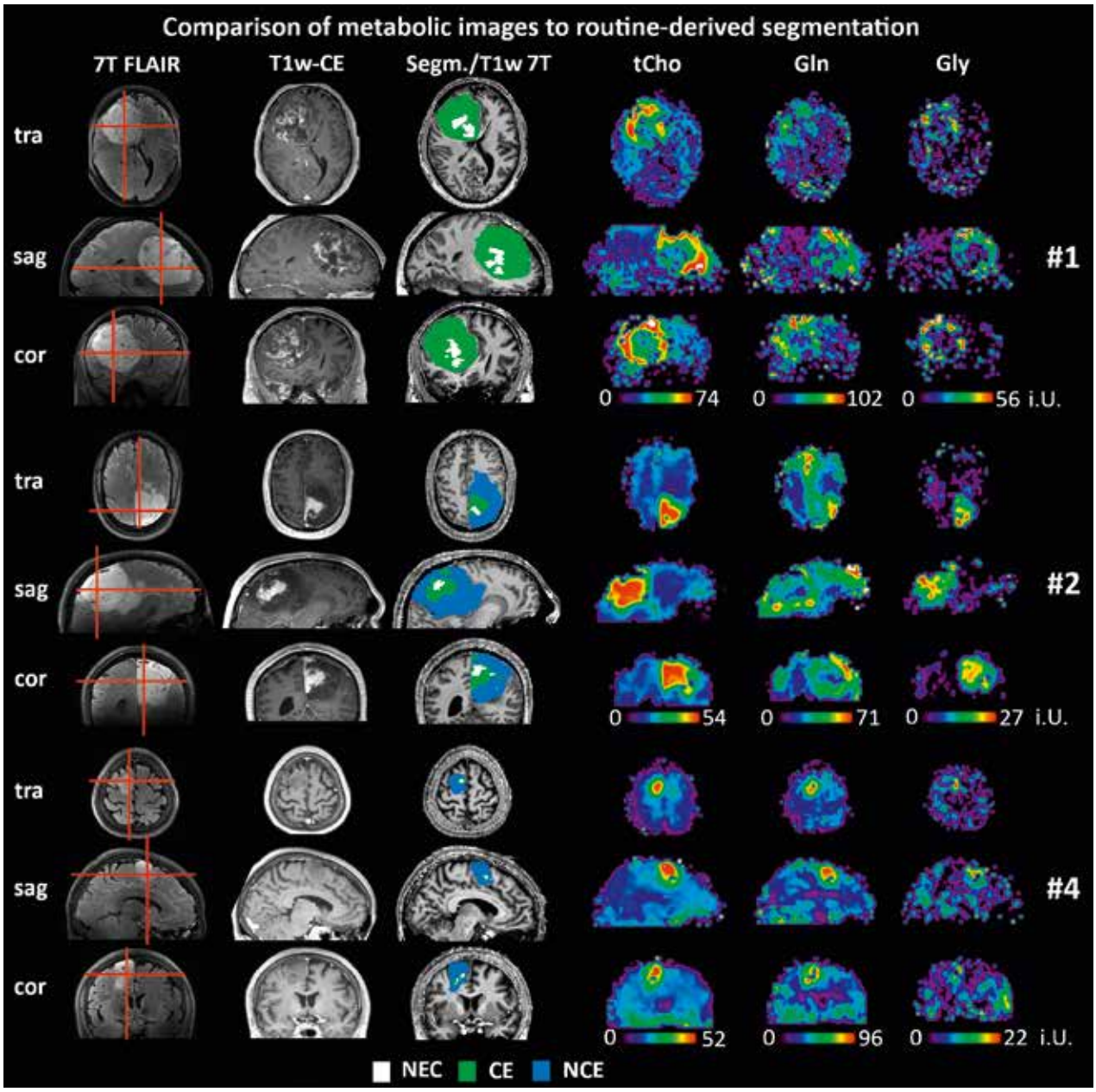
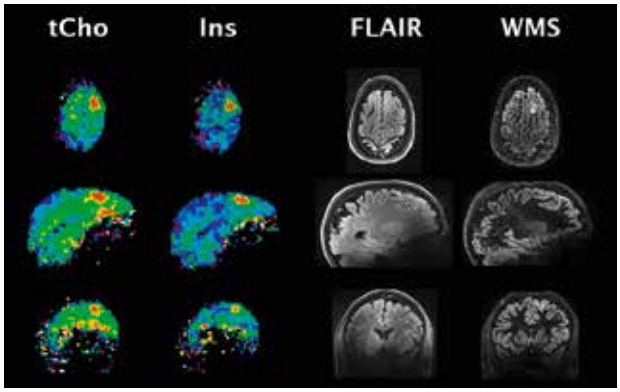


Photo: Neurosurgery

7T MRSI allows for the differentiation of metabolites such as glycine and glutamine with high resolutions, something which is not possible at low field strengths. In contrast to neuroradiological tumour segmentation, we see strong correlation and different metabolic profiles between necrosis, contrast enhancement and oedema.

Work to implement another study on epilepsy (The combination of preoperative 7T and intraoperative 3T magnetic resonance imaging in epilepsy patients for improved epilepsy surgical outcome), which combines modern morphological and metabolic imaging, was started in July 2020. Preliminary results appear promising for resolving metabolic changes in epilepsy-associated diseases more effectively than ever before (see example image).



Preliminary results of 7T-MRSI for epilepsy: Choline and myo-inositol hotspot in a patient with focal cortical dysplasia. There is also evidence of a strong match with morphological imaging.

Photo: Neurosurgery

A number of project proposals were submitted in partnership with the University of Vienna's Institute of Analytical Chemistry (Univ.-Prof. Gunda Köllensperger), targeting future collaboration regarding the combination of metabolic imaging and analytical methods/metabolomics such as mass spectrometry for imaging validation. This collaboration is an important next step in defining the potential of MRSI as a clinical tool. Existing international collaborations (Metabolic Imaging of Tumours – Massachusetts General Hospital, USA; Machine Learning Applications – Icometrix, Leuwen, BE; Improved 7T-Shimming – MRShim, Reutlingen, DE) were successfully continued.

Outlook and goals

- Start of research activities with the new intraoperative MRI scanner
- Implementation of highly precise preoperative localisation of important areas for memory, speech and motor function using functional MRI.
- Cooperation with the High Field MR Centre for clinical testing and further development of modern molecular imaging
- Integration of modern pre- and intraoperative MR methods in surgical neuronavigation
- Studies on the application of these methods in the treatment of brain tumours and epilepsy
- Joint evaluation of metabolic and quantitative images with the neurosurgical research laboratory, the neuroradiological team at the Division of Neuropathology and Neurochemistry and other partner institutions.
- Development of combined metabolomics and radiomics systems.

Microneurosurgery Laboratory 8H

Headed by: Matthias Millesi
Deputy: Aygül Wurzer

Equipment
The microsurgical laboratory on level 8H is used for training and continuing education in neurosurgical operating techniques. Eight workstations, each equipped with a microscope, are routinely available for this purpose. For workshops, the facility can be expanded to up to 16 workstations.

One master workstation is equipped with a high-quality surgical microscope or endoscope with images shared on monitors in the laboratory. A complete set of micro-neurosurgical instruments is available for training neurosurgical skills.

Photos: Neurochirurgie

Photo: Neurosurgery

Innovations in 3D visualisation
A robotic camera system was developed in cooperation with the Austrian Center for Medical Innovation and Technology (ACMIT) for high-resolution, three-dimensional recording of anatomical preparations. As part of the project, the existing surgical microscope was also upgraded with a high-resolution 3D photo and video system. In combination with the 3D projectors at the Department of Neurosurgery, the new set-up now provides a complete 3D system for teaching.

Bypass workshop
Founded 30 years ago by Professor Koos, the European Workshop on Basic Techniques of Microsurgery and Cerebral Revascularisation is one of the longest-running microsurgical bypass courses in Europe. The international course, which has already been attended by almost 500 colleagues from Austria and abroad, is designed to teach different types of microsurgical anastomoses and nerve coaptations. Our programme includes hands-on training on synthetic and animal models, case presentations and lectures by international experts.

Endoscopic pituitary surgery workshop
To safely perform the endoscopic transnasal surgical technique, training in anatomic workshops is critical. Hands-on workshops have been held every year since 2003 to provide practical training in endoscopic techniques, or access anatomy with a focus on the endoscopic view of structures.
Twelve fully equipped endoscopy workstations and a 3D endoscopy master station are available in the microsurgical laboratory on level 8H for this course.

DTI – Tractography Workshop
The DTI Workshop has been held 12 times since 2010 to teach participants about the fibre tract anatomy of the brain and deepen their understanding of the correlation with magnetic resonance DTI tractography. Here, the main focus is on the combination of dissection of fibre connections on the cadaver specimen and a virtual dissection of the MRI images using a DTI tractography software. Participants are given the opportunity to familiarise themselves with the anatomical basis of white matter anatomy and the physical principles and clinical relevance of fibre tract imaging using tractography.

Besides the 40 courses held at regular intervals for participants from a wide range of disciplines (neurosurgery, trauma surgery, plastic surgery), microsurgical dissection exercises are offered for students in the form of lectures. Microneurosurgery Laboratory 8H was also used for demonstration purposes during the citywide Long Night of Research.

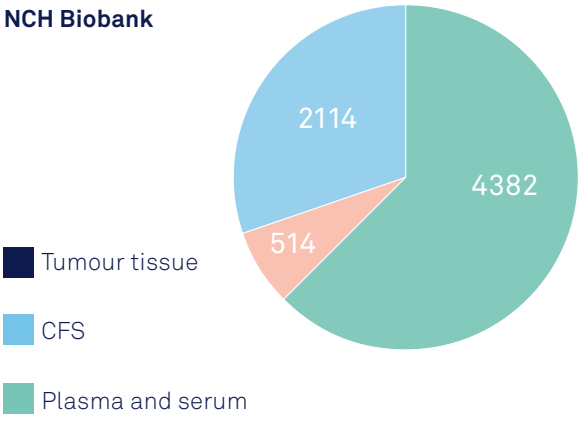
Neurosurgical Research Laboratory

Neurosurgery lab: fighting cancer with molecular biology

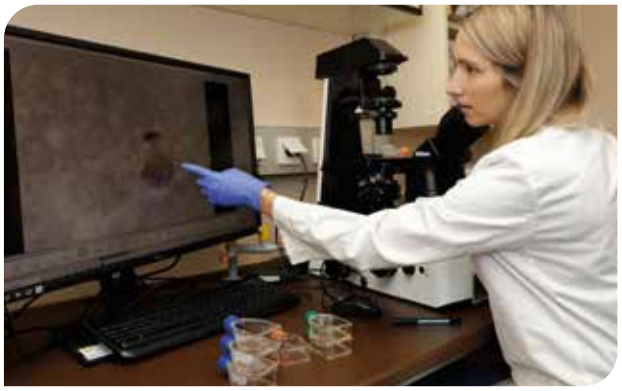
Headed by: Daniela Lötsch-Gojo
Deputy: Georg Widhalm
Team: Tanja Peilnsteiner, Alexandra Lang

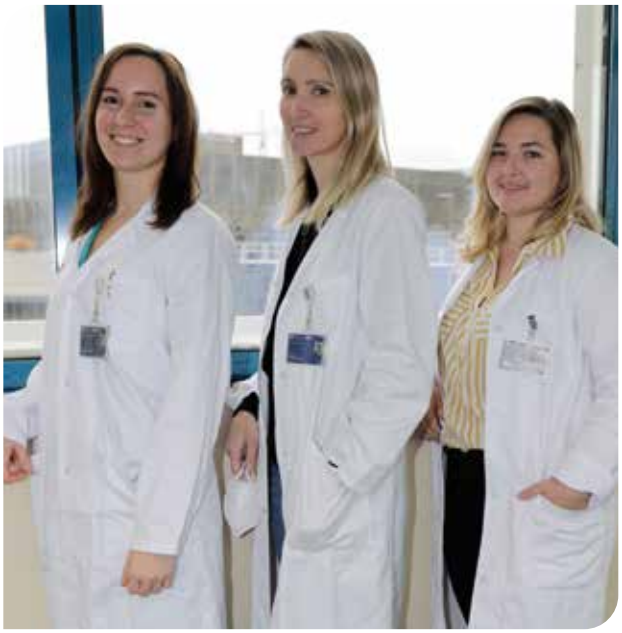
The origins of the Neurosurgical Research Laboratory date back to 1984, when Professor Wolfgang Koos set up a laboratory on the same level as the operating theatre at the newly constructed Department of Neurosurgery facilities. This made it possible for neurosurgeons to produce histological findings within minutes, and, as a result, to adjust intraoperatively the type and procedure of the surgery (biopsy, partial resection or complete resection). This led to a great increase in expertise in intraoperative frozen section diagnostics at the Department of Neurosurgery at MedUni Vienna and University Hospital Vienna. By that time, tissue samples of pituitary adenomas, meningiomas and gliomas were already being archived, meaning that immunohistochemical studies on the proliferation kinetics of these brain tumours could be carried out at a very early stage, and successfully correlated with the prognosis or with the risk of tumour recurrence (Kitz K et al: Proliferation in pituitary adenomas: measurement by MAb KI 67. Acta Neurochir Suppl (Vienna). 1991;53:60-4). The laboratory has continued to build on its expertise, and has now started to build up a neurosurgical biobank that includes tumour tissue, blood samples and cerebrospinal fluid samples.

NCH Biobank



Daniela Lötsch-Gojo took over as head of the neurosurgical research laboratory in May 2020, with the aim of bringing the facility up to date and setting up neuro-oncology research projects. Since embarking on her research career at the Neuromed Campus of the Kepler University Hospital in Linz and later at the Cancer Research Centre at MedUni Vienna (from 2012), she has already gained a lot of experience in basic research on paediatric and adult brain tumours. During the course of her extensive career, she has set up a successful national and international research network.
Under her leadership, numerous devices have already been acquired to enable independent scientific work in the neurosurgery laboratories.



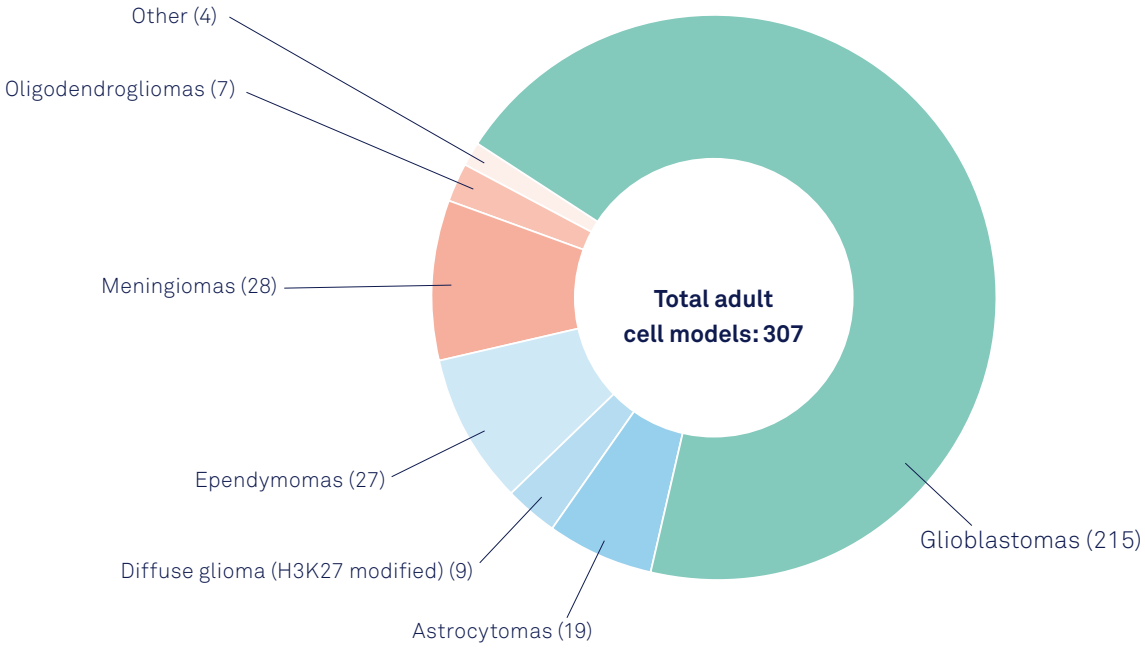


Lab team: Tanja Peilnsteiner (left), Daniela Lötsch-Gojo (centre), Alexandra Lang (right)

Photos: Wei-Te Wang

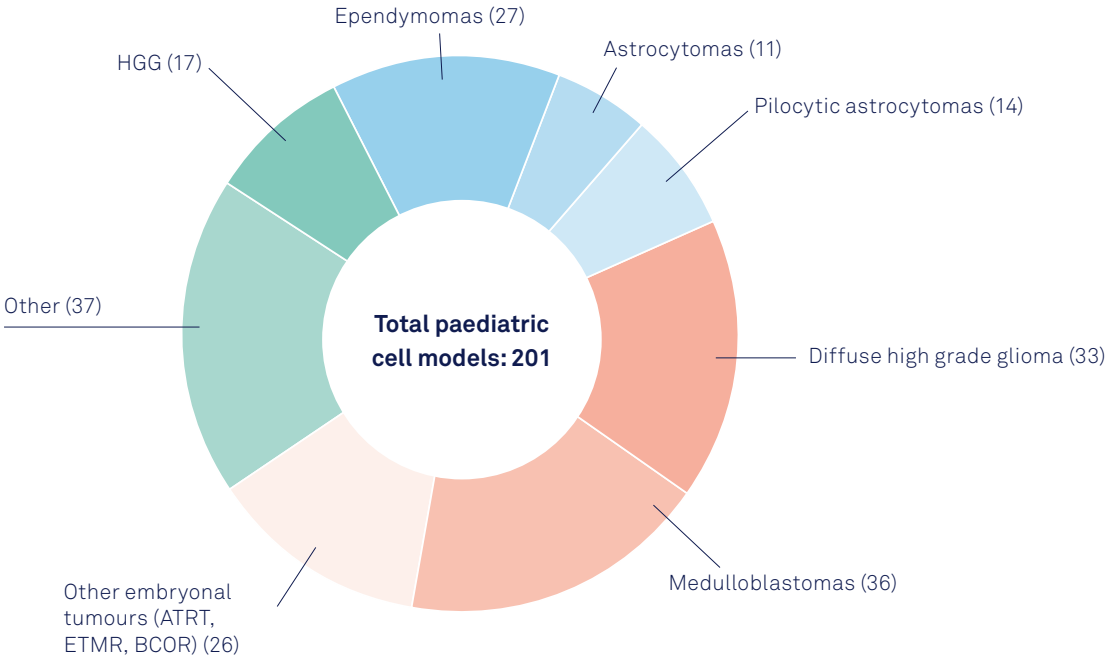
In addition to setting up the neuro-biobank, cell cultures of different brain tumour entities have been cultivated at the neurosurgical research laboratory since 2009 (in cooperation with the Center for Cancer Research) for use in molecular biological analyses. To date, we have established a total of 307 cell models from adult brain tumour tissue samples.

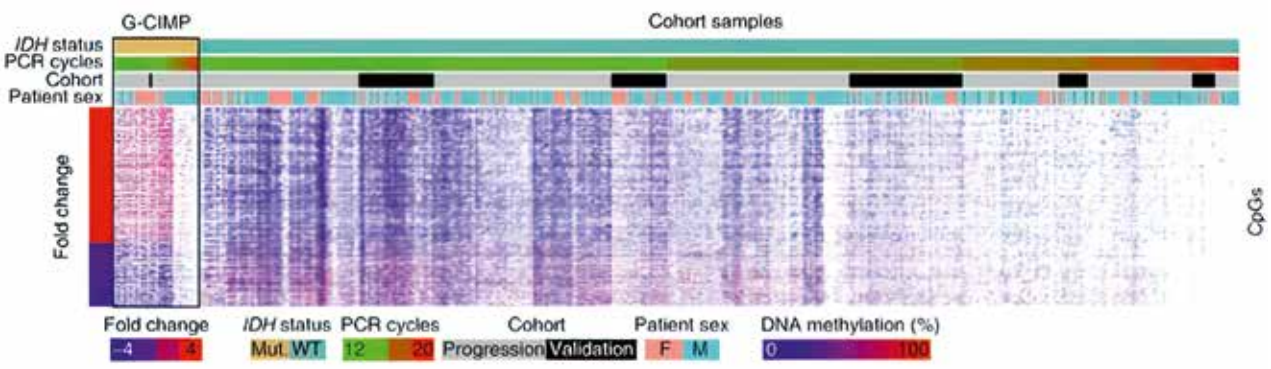
Number of primary cell cultures established from adult brain tumour samples in recent years



As the Department of Neurosurgery operates on numerous paediatric patients, tissue cultures are also generated from these tumour samples – some of which represent very valuable rare cell models. In recent years, 201 primary cell models have been established.

Number of primary cell cultures established from tissue samples from paediatric brain tumour patients





DNA methylation levels of IDH-mutated reference samples and glioblastoma samples (IDH-wiltype) of the study cohort

Research focuses

Since especially for glioma patients, despite resection and aggressive radio/chemotherapy, the median survival is only 15-18 months, discovering new diagnostic, prognostic as well as therapeutic biomarkers is essential. In this light, expanding our biobank is indispensable for performing genome-wide molecular analyses to better understand complex diseases and to gain relevant insights with regard to personalised therapies.

This was also shown in a study conducted in cooperation with the Division of Neuropathology and Neurochemistry and the Research Center for Molecular Medicine (CeMM) of the Austrian Academy of Sciences. Using DNA methylation analysis, clinically relevant tumour properties – such as immune cell infiltration or transcriptional subtypes – could be depicted at the epigenetic level and the characteristic changes they undergo as the disease progresses shown.

The research lab also focuses on discovering the molecular mechanisms underlying 5-Aminolevulinic acid (5-ALA) fluorescence-guided surgical removal of brain tumours in general, and gliomas in particular. 5-Aminolevulinic acid (5-ALA) accumulates in tumour cells where it is converted to fluorescent protoporphyrin IX, which glows in blue light, making brain tumors "visible". Protoporphyrin IX is formed by haem biosynthesis. Different enzymes of haem biosynthesis are analysed in the course of various studies in order to identify factors that influence protoporphyrin IX fluorescence and subsequently to be able to influence them, too. During the research, molecular genetic analyses as well as histopathological and immunohistochemical results are combined.

Discovery of new therapeutic targets using innovative preclinical models

Daniela Lötsch-Gojo succeeded in creating two-dimensional and spheroidal cell models using fresh material from glioblastoma patients in cooperation with the Department of Neurosurgery and the Clinical Institute of Neurology (Hainfellner) while working on her PhD at Walter Berger's laboratory. In cooperation with the Department of Pediatrics and Adolescent Medicine, she was also able to culture rare paediatric brain tumour models with very specific alterations (including medulloblastomas and ependymomas). These models serve as the basis for a wide variety of research projects and enable the molecular characterisation of these tumours as well as the discovery and verification of new therapy targets. Using these unique cell models, she is now collaborating with the Cancer Research Centre and the Department of Paediatrics and Adolescent Medicine on the prestigious ITCC-P4 project (www.itccp4.eu, total funding: EUR 18,131,961), which is establishing a preclinical therapy testing platform for paediatric cancers. Published in Acta Neuropathologica, a recent paper describing FGFR as a new therapeutic target in aggressive paediatric ependymomas was only made possible because Lötsch-Gojo had access to these valuable cell models. Several future research projects build on this publication, with the focus on inducing cell differentiation by means of new therapies in cell and organoid models of ependymoma, and on slowing down tumour growth. A project from this research focus, titled Maturation-targeting therapies – an innovative strategy for aggressive ependy, was selected in the final call of the Fund of the City of Vienna for Innovative Interdisciplinary Cancer Research, and received funding of EUR 79,530. This project is set to be significantly expanded in cooperation with Marcel Kool, group leader at the Princess Maxima Center in Utrecht, NL.

Both Ms Lötsch-Gojo and Mr. Kool act as PIs for the Targeting undifferentiated cellular states to combat aggressive ependymoma (TRAFO, funding: EUR 500,000) project, which now has approval to submit a full proposal to the Fight Kids Cancer Call 2021-2022. A medical student (Theresa Zehetbauer) is also working on the description of differentiation markers in ependymoma for her diploma thesis. Lötsch-Gojo is the junior supervisor, and Christian Dorfer the senior supervisor. Another collaborative project (Department of Pediatrics and Adolescent Medicine, St. Anna Children's Cancer Research and University of Veterinary Medicine Vienna) on the topic of ependymomas, entitled Map and manipulate cellular states of ependymoma – MMiraCLE, is currently being reviewed as part of a research group submission (Austrian Science Fund, EUR 1,492,677.74).

Immortalisation mechanisms in aggressive brain tumours

Another research focus is uncovering the molecular basis for cell immortalisation in high-grade paediatric and adult brain tumours. In cooperation with the Cancer Research Centre and the Neuromed Campus at Kepler University Hospital in Linz, we have already published several outstanding papers on this topic (cumulative impact factor: 57). Thanks to her many years of experience in this area of research, Ms. Lötsch-Gojo also received a Hertha Firnberg Research Grant from the Austrian Science Fund after her PhD (thesis title: TERT promoter mutations and cancer aggressiveness, T906-B28; funding: EUR 230,010). This project is currently in the final phase. A follow-up project entitled Receptor tyrosine kinase signalling activation as driver for TERT promoter mutations in glioblastoma deals with the biological basis of cell immortalisation and received a research grant of EUR 35,000 from the Comprehensive Cancer Center's cancer research initiative. The mechanisms of cell immortalisation in ependymoma are currently also being researched in the course of a PhD thesis by a student at the Centre for Cancer Research (supervisor: Walter Berger).

Additional cooperative research projects undertaken at the research laboratory

The Neurosurgical Research Laboratory is also involved in various collaboration projects within the Department of Neurosurgery. Research is currently under way for a project headed by Friedrich Erhart which has secured funding from the Mayor's Fund of the City of Vienna (title: miRNAs as modulators to make glioblastomas susceptible to immunotherapies; funding: EUR 20,000).

Another project, led by Dorian Hirschmann, is investigating the connection between oedema and epilepsy in meningiomas. This idea was funded by the City of Vienna's Fund for Innovative Interdisciplinary Cancer Research (title: Pathophysiology of Edema Formation and Epilepsy in Intracranial Meningiomas: A Study on Tissue and CSF Molecules; funding: EUR 63,757.50). In order to carry out this project, tumour samples and cerebrospinal fluid for metabolomics and lipidomics measurements are taken in the laboratory at the Institute for Analytical Chemistry at the University of Vienna under Gunda Köllensperger.

Daniela Lötsch-Gojo is also a partner in an Austrian Research Promotion Agency project led by JLP Health (Josef Penninger) at the Vienna Biocenter and Berger, at the Center for Cancer Research. The aim of this joint project is to carry out a preclinical investigation of the combination of artemisinin with 5-ALA before initiating a phase I/II clinical trial. At the same time, the research lab is also involved in a review on this topic in the Journal of Experimental Medicine, titled A whole genome scan for artemisinin cytotoxicity reveals a novel therapy for human brain tumours.

Having previously built up a wealth of experience of establishing orthotopic glioblastomas in mouse brains in the course of an earlier research project, she also completed the Introduction to Laboratory Animal Science course at the University of Veterinary Medicine Vienna (Vetmeduni). The goal is now to build up this technology in cooperation with the Department of Pediatrics and Adolescent Medicine, with Walter Berger in charge of the animal stables, so that it can be used for preclinical research into paediatric and adult brain tumours.

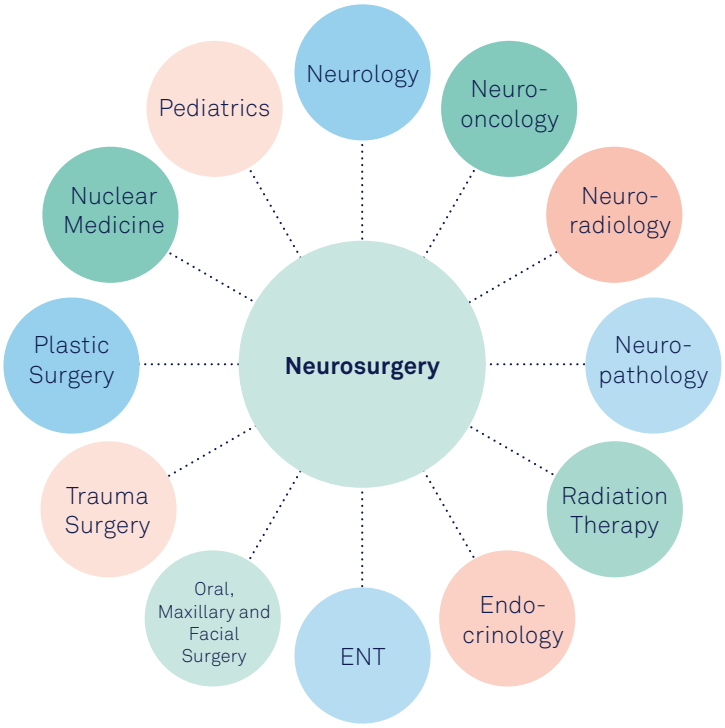
» Interdisciplinary boards

Neurosurgery as a hub for interdisciplinary cooperation

Cooperation with other disciplines is frequently essential for the treatment of patients with often complex neurosurgical diseases.
In many cases, close coordination with the departments of oncology and radiotherapy is a necessary part of follow-up treatment and further therapy for oncological patients. The same applies to paediatric patients. When it comes to planning and performing operations on the skull base, our Department must also discuss surgical procedures with our colleagues from the Department of Oral, Maxillary and Facial Surgery and/or the Department of Otorhinolaryngology, and in some cases, we go on to conduct the surgical intervention together. Coordination with the Department of Neurology and the Department of Radiology and Nuclear Medicine is required for planning and discussing multimodal management of cerebrovascular diseases. In the case of conditions such as epilepsy and other neurological diseases, the Department of Neurosurgery works closely with the Department of Neurology. In all these tasks, we organise or participate in various interdisciplinary boards.

Name	Departments involved	Members (individuals)	Meets	Organisation/ administration
Neuro-oncology Tumour Board – Adults	Department of Neurosurgery, Department of Neuropathology, Department of Neuro-oncology, Department of Biomedical Imaging and Image-guided Therapy (Neuroradiology)	Karl Rössler Georg Widhalm Barbara Kiesel	Weekly (Thursdays)	Georg Widhalm
Tumour Board Neurooncology Children	Department of Neurosurgery, Department of Neurology, Department of Radiology and Nuclear, Medicine (Neuroradiology)	Christian Dorfer Andrea Reinprecht Barbara Kiesel	Weekly (Mondays)	Christian Dorfer
Vascular Board	Department of Neurosurgery, Department of Biomedical Imaging and Image-guided Therapy (Neuroradiology)	Karl Rössler Gerhard Bavinzski Wei-Te Wang Philippe Dodier Wolfgang Serles Josa Frischer Arthur Hosmann	Weekly (Mondays)	Gerhard Bavinzski Wei-Te Wang Philippe Dodier
Movement Disorder Board	Department of Neurosurgery, Department of Neuropathology, Department of Neurology, Department of Paediatrics and Adolescent Medicine	Klaus Novak Mario Mischkulnig Friedrich Erhart	As required	Klaus Novak

The Department of Biomedical Imaging and Image-guided Therapy is always involved in the discussion of imaging procedures.
In addition to the boards organised by the Department of Neurosurgery, doctors from our department also participate in numerous interdisciplinary boards overseen by other departments.



Name	Departments involved	Members (individuals)	Meets	Organisation/ administration
Epilepsy Surgery Board – Children	Department of Neurosurgery Department of Pediatrics and Adolescent Medicine, Department of Biomedical Imaging and Image-guided Therapy (Neuroradiology)	Karl Rössler Christian Dorfer Johannes Herta Matthias Tomschik Jonathan Wais Michael Sadowicz	As required	Karl Rössler Christian Dorfer
Epilepsy Surgery Board – Adults	Department of Neurosurgery, Department of Neurology, Department of Biomedical Imaging and Image-guided Therapy (Neuroradiology)	Karl Rössler Christian Dorfer Johannes Herta Matthias Tomschik Jonathan Wais Michael Sadowicz	As required	Karl Rössler Christian Dorfer
Pituitary Board	Department of Neurosurgery, Division of Endocrinology and Metabolism	Christian Matula Matthias Millesi	As required	Christian Matula Matthias Millesi
Skull Base Board	Department of Neurosurgery, Department of Otorhinolaryngology, Department of Biomedical Imaging and Image-guided Therapy (Neuroradiology)	Christian Matula Matthias Millesi Walter Saringer Alexander Micko Brigitte Gatterbauer	Twice monthly	Christian Matula Matthias Millesi

Neuro-oncology Tumour Board

The Neuro-oncology Tumour Board has been held weekly at the Department of Neurosurgery since 2005. In addition to experts from the Department of Neurosurgery, this interdisciplinary meeting is also attended by representatives from the departments of radiology, nuclear medicine, neuropathology, oncology, radiotherapy and neurology. The Neuro-oncology Tumour Board discusses all patients with a tumour of the central nervous system – such as brain tumours or metastases – as well as rare tumour entities in cases that require interdisciplinary consultation. This allows an individual treatment plan to be drawn up for each patient.
On average, the case notes of around 10–15 tumour patients are reviewed and discussed on an interdisciplinary basis at each meeting of the Neuro-oncology Tumour Board.

Vascular Board

The Department of Neurosurgery Vascular Board convenes weekly. The events take the form of a seminar within the framework of the Clinical Neuroscience (CLINS) postgraduate PhD programme, and an interdisciplinary discussion of recent cerebrovascular neurosurgical cases with the participation of doctors from the departments of neurosurgery, neurology and radiodiagnostics. Interdisciplinary coordination of treatment strategies is of particular importance, given the numerous therapeutic options available to us for the multimodal management of cerebrovascular diseases at the Department of Neurosurgery. The therapy recommendations made in the course of this board's meetings are implemented as soon as possible.

In addition to planning future interventions, giving debriefings on the elective and acute interventions carried out in the recent weeks is of particular importance for two reasons. Firstly, the suitability of the defined treatment strategies can be checked immediately and secondly because they allow cases that were treated acutely – i.e. without first being presented to the Vascular Board – to be analysed conclusively. The majority of the patients discussed in these reviews suffered from cerebral aneurysms, angiomas and arteriovenous fistulas.

Pituitary Board

Held since 2014, the interdisciplinary Pituitary Board meets to discuss therapies, disease progression and complicated pathologies related to the pituitary gland. Working alongside colleagues from endocrinology, radiology, neuropathology and Gamma Knife radiosurgery, the meetings centre on designing tailored multimodal therapy concepts.

Spinal Board

Collaboration with the Department of Orthopedics on spinal surgery led to the establishment of a separate board that deals specifically with spine conditions. Organised by the Department of Orthopaedics, it is interdisciplinary in character. In addition to permanent representation from neurosurgery and radiology, representatives from other departments (thoracic surgery, oncology) are also invited to take part on a case-by-case basis. The Spinal Board meets once a week. Although discussions of patients with degenerative diseases of the spine forms the primary focus, it also deals with tumours, post-traumatic changes and congenital malformations. The aim is to use the interdisciplinary discussions to determine an individual treatment plan.
In addition to delivering the best possible level of clinical care, collaboration between departments represented on the board is aimed at developing new treatment strategies, implementing new therapy options and enhancing the scientific processing of surgical results.

Paediatric boards

Pediatric Tumour Board
Children with tumours of the central nervous system are discussed in the multidisciplinary Pediatric Tumour Board.
It has been an integral part of patient management since 1994. Its members come from neuroradiology, neurosurgery, paediatric neuro-oncology, neuropsychology, radiotherapy, neuropathology, with other specialists participating on a case-by-case basis. The board's discussions centre on patients undergoing therapy and check-up testing, as well as newly diagnosed patients and patients referred to the department in light of our centre's status as a national reference point for low-grade gliomas, CNS germ cell tumours and AT/RT. External patients referred to the Department for a second opinion are also discussed.

Pediatric Epilepsy Board
Patients are discussed at a regular multidisciplinary paediatric epilepsy conference reserved for paediatric cases only. Participants include paediatric epileptologists and neurosurgeons, neuroradiologists, neuronuclear physicians and neuropsychologists.

Dysraphy Board
An interdisciplinary meeting for patients with dysraphic disorders has been held regularly at the Department of Neurosurgery in Vienna since 2013. In addition to doctors from our department, it is attended by colleagues working in neuropaediatrics, paediatric surgery and paediatric urology as well as neuroradiology. As the different forms of spinal dysraphia are such rare and highly complex clinical conditions, the patients affected by them benefit considerably from interdisciplinary, holistic case management. Initial presentations, surgical indications, neuroradiological, neurological and urological findings and examination results are discussed and further procedures are decided on in these meetings. Students and doctors in training also have the opportunity to attend so that they can learn about the management of these very rare diseases. It convenes at tri-monthly intervals.

Movement Disorder Board

The Movement Disorder Board was established as an interdisciplinary case conference in 2011. Besides the Department of Neurology, it is attended by experts working in neurology, paediatrics, radiology and neurosurgery. Reports are prepared for patients with complex movement disorders after a thorough neurological assessment (medical history, neurological status, genetics, neuroradiological findings, clinical findings and classification of the movement disorder), including detailed video documentation, with treatment strategies established on a case-by-case basis. Convened at one to three-month intervals, the Movement Board meeting is held at the Department of Neurosurgery.

Interdisciplinary Pain Conference

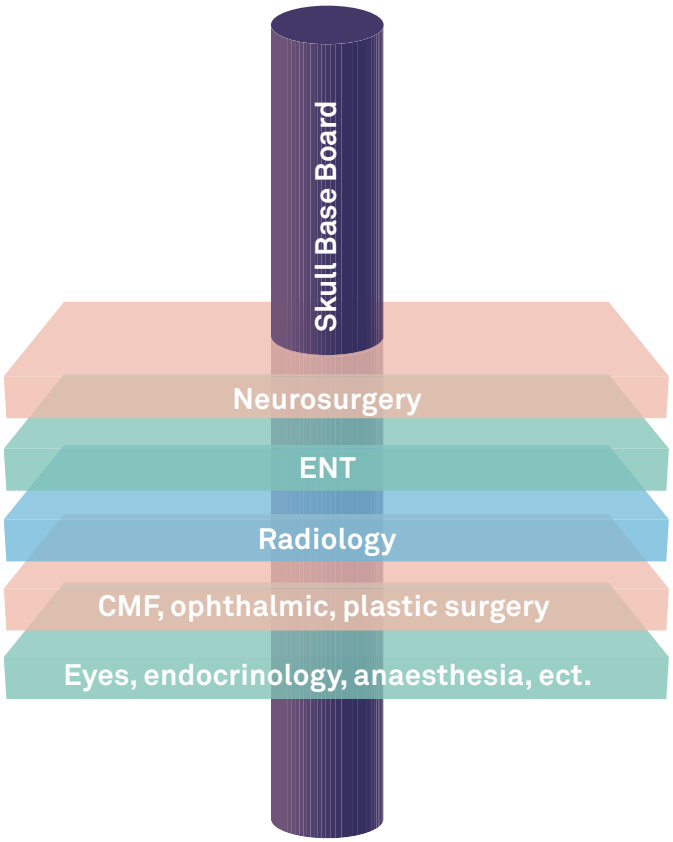
In selected difficult cases, the Interdisciplinary Pain Conference provides a suitable framework for neurosurgeons, neurologists, anaesthetists and, if necessary, other referring disciplines to discuss interdisciplinary treatment concepts.

The Interdisciplinary Pain Conference is organised once a month by the Department of Anesthesia, Critical Care and Pain Medicine.

Skull Base Board

In recent decades, close cooperation with other departments, especially with the Department of Otorhinolaryngology, in the field of skull base surgery has laid the foundation for the establishment of a separate Skull Base Board, which is organised by the Department of Neurosurgery and the Department of Otorhinolaryngology. The board was officially established in 2010. Held every 14 days at the Department of Radiology, these meetings bring together all of the departments involved. With representatives from radiology, oncology, radiosurgery, neurosurgery and otorhinolaryngology as its permanent members, the board's conferences are specifically designed to be interdisciplinary exchanges.

Skull Base Board structure – a paradigm of interdisciplinary cooperation



Boards of the Gamma Knife Radiosurgery Working Group

The Gamma Knife can be used to treat a wide range of different diseases. While most cases involve metastases, a wide variety of benign tumours are also treated with it. Besides vascular pathologies, the technology also plays a role in the treatment of functional neurological diseases and pain patients.

In light of this broad scope of applications, senior Gamma Knife doctors (Josa Frischer and Brigitte Gatterbauer) are part of the following interdisciplinary boards:

- Neuro-oncological Tumour Board
- Vascular Board
- Skull Base Board
- Pituitary Board

» Fellowships, prizes and honours

Fellowships

The following staff members were able to complete stays abroad/fellowships at renowned international universities in spite of the difficulties associated with the pandemic:

- Matthias Millesi, clinical fellowship, University of Toronto, Canada
- Alexander Micko, research fellowship, Keck School of Medicine, University of Southern California, USA

PhDs/post-doc theses

The following members of the team were awarded their PhDs: Philippe Dodier (N790), Friedrich Erhart (N790), Arthur Hosmann (N094), Matthias Millesi (N790) and Lisa Wadiura (N094), and Arthur Hosmann, Alexander Micko and Matthias Millesi successfully presented their post-doctoral theses.

Prizes/honours

The following employees were awarded prizes/honours:

- Barbara Kiesel: MedUni Vienna Researcher of the Month October 2019
- Arthur Hosmann: Promotio sub auspiciis praesidentis rei publicae 2021
- Anna Cho: Theodor Billroth Prize of the Medical Association of Vienna 2021
- Friedrich Erhart: Herbert Tumpel Prize 2021
- Karl Rössler, Gilbert Hangel: Medical Neuroscience Cluster Award Winner 2021

Photo: MedUni Vienna/feelimage

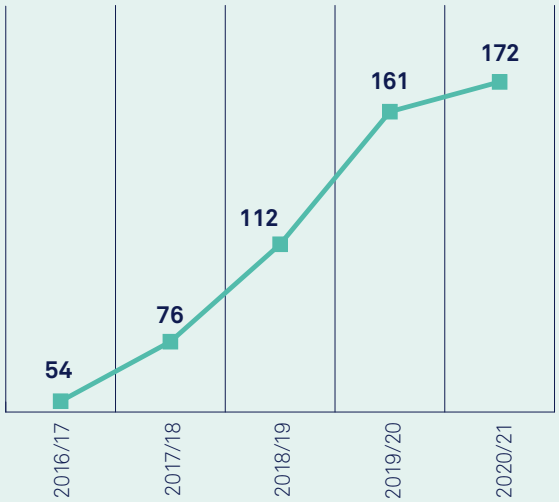
Researcher of the Month, October 2019 – Johanna Klughammer and Barbara Kiesel
The Researcher of the Month jury awarded the October 2019 prize to Johanna Klughammer and Barbara Kiesel for their paper The DNA methylation landscape of glioblastoma disease progression shows extensive heterogeneity in time and space, which was published in top journal Nature Medicine (IF 32,621). www. meduniwien.ac.at/web/forschung/researcher-of-the-month/archiv/2019-oktober-johannaklughammer-und-barbara-kiesel/

» Scientific achievements

LOM points for research and teaching

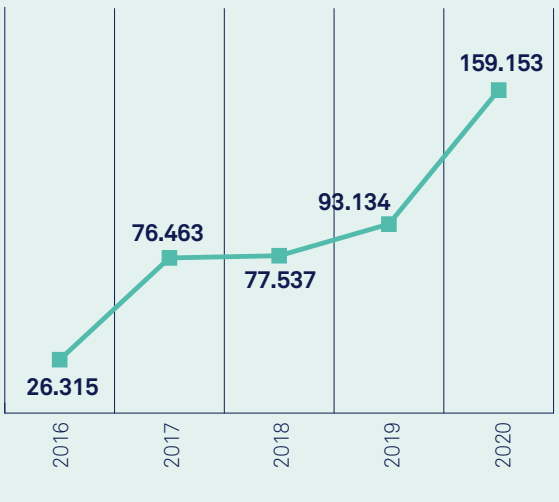
At MedUni Vienna, LOM points, among other things, are used to document performance and prepare the intellectual capital statement on research and teaching. Performance criteria (LOM research points) include publications, lectures, visiting/incoming researchers, appointments to scientific or university committees, posts held on academic journals, and prizes. Teaching performance criteria (LOM teaching) include diploma theses and dissertations supervised and completed at the department; other teaching services include seminars and lectures held, as well as the organisation and supervision of Clinical Practical Year (KPJ-students-traineeships).
Despite the ongoing pandemic which began in March 2020, as well as multiple lockdowns, the Department of Neurosurgery was particularly keen to support MedUni Vienna students in their academic progress and expand the range of continuing education courses it offers.

LOM teaching points



This expansion of neurosurgery teaching is reflected both in our figures and the increase in LOM teaching points in each academic year.

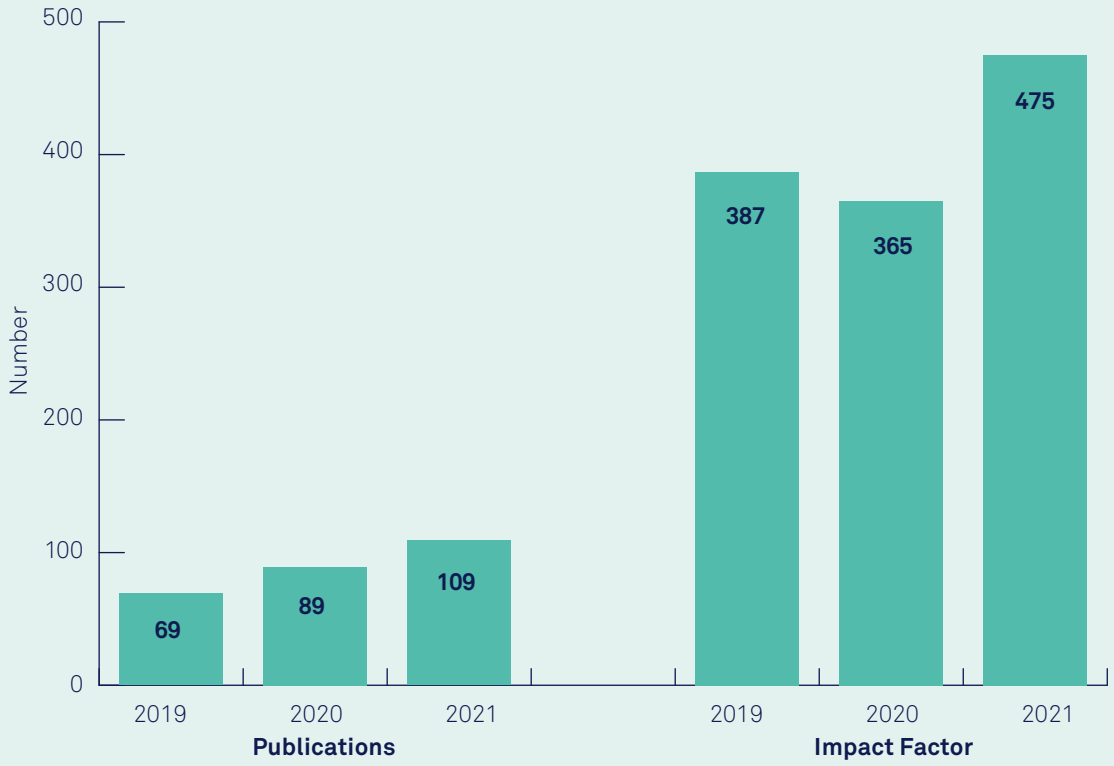
LOM research points



There was also a noticeable increase in the number of LOM points awarded for research.

The increase in LOM points in the last three years was achieved due to a significant increase in the number of scientific publications and the resulting increase in impact factors, among other things.

Publications by the Department of Neurosurgery 2019–2021



List of publications 2019

1. **Dodier P,** Auzinger T, Mistelbauer G, **Wang WT,** Ferraz-Leite H, Gruber A, Marik W, **Winter F,** Fischer G, **Frischer JM, Bavinzski G:** Novel software-derived workflow in EC-IC bypass surgery validated by transdural ICG videoangiography. World Neurosurg (2019). doi: 10.1016/j.wneu.2019.11.038. **IF: 1.723**

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3. Arfsten H, **Cho A,** Freitag C, Raderer M, Goliasch G, Bartko PE, Wurm R, Strunk G, Gisslinger H, Marosi C, Kornek G, Zielinski C, Hülsmann M, Pavo N. GDF-15 in Solid versus Non-Solid Treatment-Naïve Malignancies. Eur J Clin Invest. 2019 Nov;49(11): e13168. **IF: 4.686**

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7. Wulkersdorfer B, Bauer M, Karch R, Stefanits H, Philippe C, Weber M, **Czech T,** Menet MC, Declèves X, Hainfellner JA, Preusser M, Hacker M, Zeitlinger M, Müller M, Langer O.: Assessment of brain delivery of a model ABCB1/ABCG2 substrate in patients with non-contrast-enhancing brain tumors with positron emission tomography. EJNMMI Res. 2019 Dec 12;9(1):110. doi: 10.1186/s13550-019-0581-y. **IF: 3.0**

8. Stefanits H, Milenkovic I, Mahr N, Pataraia E, Baumgartner C, Hainfellner JA, Kovacs GG, Kasprian G, Sieghart W, Yilmazer-Hanke D, **Czech T.**: Alterations in GABA(A) Receptor Subunit Expression in the Amygdala and Entorhinal Cortex in Human Temporal Lobe Epilepsy. J Neuropathol Exp Neurol. 2019 Nov 1;78(11):1022-1048. **IF: 3.46**

9. Senfter D, Samadaei M, Mader RM, Gojo J, Peyrl A, Krupitza G, Kool M, Sill M, Haberler C, Ricken G, **Czech T,** Slavc I, Madlener S.: High impact of miRNA-4521 on FOXM1 expression in medulloblastoma. Cell Death Dis. 2019 Sep 20;10(10):696. doi: 10.1038/s41419-019-1926-1. **IF: 5.959**

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11. Gudrun Gröppel, Christian Dorfer, Sharon Samueli, Anastasia Dressler, Angelika Mühlebner, Daniela Prayer, **Thomas Czech,** Martha Feucht: Single stage epilepsy surgery in children and adolescents with focal cortical dysplasia type II - Prognostic value of the intraoperative electrocorticogram. Clin Neurophysiol. 2019 Jan;130(1):20-24. doi: 10.1016/j.clinph.2018.09.023. Epub 2018 Nov 14. **IF: 3.708**

12. Halbritter F, Farlik M, Schwentner R, Jug G, Fortelny N, Schnöller T, Pisa H, Schuster LC, Reinprecht A, **Czech T, Gojo J,** Holter W, Minkov M, Bauer WM, Simonitsch-Klupp I, Bock C, Hutter C.: Epigenomics and Single-Cell Sequencing Define a Developmental Hierarchy in Langerhans Cell Histiocytosis. Cancer Discov. 2019 Oct;9(10):1406-1421. doi: 10.1158/2159-8290.CD-19-0138. Epub 2019 Jul 25. **IF: 26.37**

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