UNIVERSITY HOSPITAL

Institute of Radiology

Department of Neuroradiology

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Research focus
- 7 Tesla ultrahigh-field-MR tomography
- functional and metabolic MR-imaging
- neuroimmunology and multiple sclerosis
- Parkinson's disease and multisystem atrophy
- diagnostic imaging of epilepsy
- multiparametric diagnosis of brain tumors
- multimodal imaging of cerebrovascular diseases
- experimental and clinical validation of flat-panel-volume-CT
- holistic assessment of the visual system in glaucoma
- artificial intelligence in neuroradiology

Structure of the Division

Professorship: 4
Personnel: 46
- Doctors (of Medicine): 15
- Scientists: 6 (thereof funded externally: 6)
- doctoral students: 6

Clinical focus areas
- full spectrum of diagnostic and interventional neuroradiology
- multimodal diagnostics in cerebrovascular diseases, brain tumors, neurodegenerative and neuroimmunological diseases and epilepsy
- functional and metabolic high filed neuroimaging
- spinal pain management

Research

The scientific focus of the Department of Neuroradiology is on multimodal imaging, especially in stroke, inflammatory and neurodegenerative CNS diseases, brain tumors and focal epilepsy. Hereby, a paramount scientific focus is on the evaluation of new imaging modalities, in particular „interventional imaging" in ischemic stroke or subarachnoid hemorrhage. In cooperation with our clinical und industry partners, validation and optimization of intravenous and intraarterial flat-panel angiography and flat-detector volume CT is performed. Another focus is on translational research in functional and metabolic highfield MRI in neurodegenerative and neuroimmunological diseases, brain tumors and epilepsy. Moreover, there are several externally third-party funded research cooperations.

7 Tesla high-field neuroimaging
As part of a research collaboration with Siemens Healthineers, various research projects are carried out in close cooperation with the Department of Radiology and the Department of Neurology to validate and optimize clinical ultrahigh-field MRI. The focus of multiparametric and metabolic imaging has been strengthened by the appointment of Professor Moritz Zaiss in 2019, who established a distinct research unit with a focus on CEST-imaging that is closely connected to clinical ultrahigh-field MR scientists.

Functional and metabolic MR-imaging
There are several ongoing research projects in cooperation with departments and institutes at the Faculty of Medicine (Department of Psychiatry and Psychotherapy, Division of Child and Adolescent Mental Health, Division of Psychosomatics and Psychotherapy, Department of Medicine 3, Department of Neurology, Institute of Physiology and Pathophysiology, Institute of Experimental and Clinical Pharmacology and Toxicology) and at the Faculty of Business, Economics, and Marketing involving functional and metabolic MR-imaging (e.g. patients with major depressive disorders, anxiety, and eating disorders, chronic pain syndromes, and rheumatoid arthritis). Together with the Department of Neurosurgery and funded by the DFG, we evaluate and optimize multimodal imaging protocols to evaluate diffuse tumor cell spread in glioma patients.

Neuroimmunology & multiple sclerosis
In patients with multiple sclerosis (MS), 7 Tesla imaging is used to validate reproducible, independent, and sensitive imaging markers that will allow clinical trials of progressive MS to be completed in less time and with fewer resources, and that can be promptly brought into clinical routine for follow-up and therapy monitoring. By use of ultrahigh-field MRI, surrogate parameters (QSM, CEST, myelin-water imaging, Na-imaging, K-imaging) are validated in multiple sclerosis in correlation to the clinical course (outcome measures). Sodium and potassium MRI-measurements are funded by the German MS Society.

Parkinson's disease and multisystem atrophy
Idiopathic Parkinson's syndrome (IPS) can be differentiated from atypical parkinson syndromes. The atypical parkinson syndromes are characterized by a rapidly progressive course and a worse prognosis. Clinically, reliable imaging diagnostics for the early detection and differentiation of these entities is desirable. Hereby, ultrahigh-field MRI with high-resolution morphological sequences and new image contrasts for the direct visualization of the substantia nigra can improve early differential diagnosis.
Additionally, we evaluate QSM (quantitative susceptibility mapping) in patients with IPS and atypical parkinson syndromes to identify functional surrogate parameters of iron metabolism and demyelination for early diagnosis and differential diagnosis.

Epilepsy
In cooperation with the Epilepsy Center, we evaluate different multiparametric imaging strategies in the preoperative workup of patients with focal seizures refractory to medical treatment. Hereby, a major focus is set on correlation of high-resolution 3T and 7T morphologic and functional MR imaging (MR spectroscopy, diffusion tensor imaging, functional MRI, perfusion- and diffusion-weighted MRI, MR volumetry/voxel- based morphometry) with physiological parameters (EEG, MEG, WADA test, SPECT, PET).

Neurooncology
In close cooperation with our clinical partners, the department of radiooncology, the departments of neurosurgery and neurology and the clinical medical physics, the overall goal of our neurooncological research is to conceive the tumorbiology of brain tumors on an imaging basis and to use the results for better diagnostics, differential diagnostics and therapy monitoring in a translational approach. Implemented directly from clinical research into routine reporting, multiparametric imaging including dedicated diffusion, perfusion and quantitative (susceptibility-weighted) imaging for evaluation of tumor microvasculature and oxygen metabolism enables "state-of-art" care of our patients regarding initial diagnosis (differential diagnosis) and especially the reliable follow-up of brain tumors. The combination and analysis of quantitative imaging features (radiomics), allows for reliable imaging-based characterization (diagnosis and grading) of brain tumors; e.g. the differentiation of therapy associated changes from true tumor progression with 94% accuracy.

Multimodal imaging of cerebrovascular diseases
In cooperation with the Department of Neurology, we participate in several studies on acute ischemic stroke. Using multimodal imaging algorithms, including perfusion and diffusion weighted imaging, diffusion tensor imaging, susceptibility-weighted imaging, arterial spin labeling, and contrast-enhanced angiographic imaging, we evaluate the individual indication for acute stroke therapies, such as intravenous thrombolysis, intraarterial thrombectomy, and/ or other neuroprotective therapies. Main focus is the

CT- and MR-derived patient selection for mechanical thrombectomy. Another clinical and scientific focus is the evaluation and validation of new devices for mechanical thrombectomy in acute cerebral stroke. As part of the Stroke Research Consortium in Northern Bavaria (STAMINA), multiple clinical parameters of consecutive patients with acute cerebral ischemia are recorded and correlated interdisciplinary with clinical endpoints to improve treatment.

Experimental and clinical validation of flat-panel volume CT

In close cooperation with Siemens Healthineers, the Pattern Recognition Lab, and our clinical partners we further evaluate intravenous and intraarterial flat-panel volume CT, angiographic techniques, and postprocessing algorithms in cerebrovascular disease. Hereby, a focus is set on the optimized visualization of cerebral microimplants, such as stents, coils, clips, new perfusion techniques, and advanced 3D visualization. A dedicated focus is on the multimodal (one-stop) imaging and work-flow optimization in stroke patients.

Holistic assessment of the optic system in glaucoma

In cooperation with the Department of Ophthalmology we evaluate diffusion tensor imaging (DTI) using 3 and 7 Tesla MRI to assess quantitative and qualitative changes within the optical fiber tracts in glaucoma patients at a very early stage. Disorders in optical fiber tracts result in reduced fractional anisotropy (FA) and atrophy of the tracts which can be used for non-invasive and fast screening, staging and to evaluate therapeutic strategies in glaucoma. Moreover, DTI can be used to distinguish between different forms of glaucoma that require diverse treatment. Further aim is to detect pathological protein deposits in the brain tissue in patients with pseudoexfoliation glaucoma (PEXG), using highfield molecular CEST MRI, to measure the effect of these proteins on neuronal and axonal integrity and resulting cell death by means of Na-imaging, and to measure the damage along the intracranial visual pathway. Hereby, molecular CEST and Na-MRI signatures as well as structural DTI patterns are used to characterize PEX glaucoma subtypes and imaging markers will be correlated with ophthalmologic measurements and location of damage to the visual pathway in a holistic approach.

Artificial Intelligence in Neuroradiology

Neuroradiology gathers support in postprocessing acquired data through artificial intelligence and computer aided diagnosis (CAD) methods. In acute stroke, CAD can help in the estimation of prognosis. By means of automated detection and evaluation of damaged parenchyma, as well as static and dynamic brain perfusion, an individualized therapy can be initiated. AI empowers the machine-readable processing and quantification of imaging data for further treatment.

In interventional neuroradiology, AI can also help to reduce radiation dose for both, patients and physicians. We develop and evaluate new AI-algorithms, that allow 3D imaging of the brain vasculature in higher quality than previous methods by simultaneously cutting the dose by 50%.

In cooperation with our partners we evaluate AI in imaging of neurodegenerative diseases, e.g. an innovative approach for automated segmentation and quantification of brain atrophy in dementia and multiple sclerosis. Detection and monitoring of inflammatory brain lesion volume is also a promising application of AI based algorithms.

Teaching

The Department of Neuroradiology is widely involved in the training of medical students. We train residents in neuroradiology and general radiology and radiological technicians. In addition to the training of medical students in accordance with ÄAppO, the Division of Neuroradiology also conducts courses for the degree program in Medical Technology (Biological and Technical Vision) and the Chair for Pattern Recognition and the School of radiological technicians. In addition, the Department of Neuroradiology offers the lecture „Clinical Neuroimaging“ since 2014.

Together with the Institute of Diagnostic Radiology, the education of physician specialized in Diagnostic Radiology is carried out. For neuroradiology, there is full training authorization.

Selected publications

Lachner S, Ruck L, Niesporek SC, Utzschneider M, Lott J, Hensel B, Dörfler A, Uder M, Nagel AM: (2020) Comparison of optimized intensity correction methods for 23Na MRI of the human brain using a 32-channel phased array coil at 7 Tesla. Z Med Phys. 2020;30(2): 104-115

Rösch J, Mennecke A, Knott M, Hamer HM, Doerfler A, Engelhorn T:(2020) T2-sequence with contrast inversion: diagnostic value in the investigation of gray matter heterotopias. Neuroreport. 2020;31(9): 686-690

Luecking H, Doerfler A, Goelitz P, Hoelter P, Engelhorn T, Lang S: (2020)Two- to five-year follow-up of 78 patients after treatment with the Flow Redirection Endoluminal Device. Interv Neuroradiol. 2020;26(1): 38-44

Schmidt MA, Knott M, Hoelter P, Engelhorn T, Larsson EM, Nguyen T, Essig M, Doerfler A: (2020) Standardized acquisition and post-processing of dynamic susceptibility contrast perfusion in patients with brain tumors, cerebrovascular disease and dementia: comparability of post-processing software. Br J Radiol. 2020;93(1105):

Eisenhut F, Taha L, Kleibe I, Hornung J, Iro H, Doerfler A, Lang S: (2020)Fusion of Preoperative MRI and Postoperative FD-CT for Direct Evaluation of Cochlear Implants : An Analysis at 1.5 T and 3 T. Clin Neuroradiol. 2020;30(4): 729-737

Hoelter P, Muehlen I, Goelitz P, Beuscher V, Schwab S, Doerfler A: (2020)Automated ASPECT scoring in acute ischemic stroke: comparison of three software tools. Neuroradiology. 2020;62(10): 1231-1238

Macha K, Hoelter P, Siedler G, Knott M, Schwab S, Doerfler A, Kallmünzer B, Engelhorn T. Multimodal CT or MRI for IV thrombolysis in ischemic stroke with unknown time of onset. Neurology. 2020 Dec 1;95 (22)

International cooperations

Massachusetts General Hospital, Harvard, USA, Professor Chris Farrar

UCL Queen Square Institute of Neurology, London, Großbritannien, Professor Xavier Golay

Inselspital Bern, Schweiz, Professor Roland Wiest

Technische Universität Graz, Österreich, Professor Rudolf Stollberger,

Institute of Biostructures and Bioimaging (IBB), Turin, Italien, Dr. Dario Longo