Institute of Radiology
Chair of Diagnostic and Interventional Radiology

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Research Focus
- Optimization of radiation dose and image quality in computed tomography
- Functional and metabolic MRI
- Interventional radiology
- Cardiovascular imaging
- Breast imaging and gynecological radiology
- Information technology in radiology
- Experimental radiology and small animal imaging
- Musculoskeletal imaging research
- MR-physics

Structure of the Institute
Professorships: 4
Personnel: 156
- Doctors (of Medicine): 33
- Scientists: 11 (thereof funded externally: 11)
- Graduate students: 13

Clinical focus areas
- Computed tomography (CT)
- Magnetic resonance imaging (MRI)
- Angiography (including therapies)
- Conventional radiography
- Imaging
- Ultrasound
- Mammography
- Biopsies with imaging guidance

Research
Scientific focus of the Radiological Institute is clinical and translational research. Within different study groups and research projects, the clinical impact of various imaging procedures or novel technical developments is evaluated. Furthermore, the Imaging Science Institute (ISI; compare own report) is operated in cooperation with Siemens Healthcare to integrate new developments in diagnostic imaging and novel IT-solutions into the clinical routine and the academic research. Finally, experimental and pre-clinical studies are well-established in our scientific activities.

Optimization of radiation dose and image quality in computed tomography
Pt: PD Dr. M. May, Dr. M. Brand, PD Dr. W. Wüst, Prof. Dr. M. Lell, Prof. Dr. M. Uder
CT is the major contributor to overall medical x-ray exposition. Radiation induced DNA-double-strand-breaks (DSB) can be detected by immunofluorescence microscopy. Recent studies have shown a strong correlation between DSB levels and the dose deposited in blood lymphocytes of patients. A different approach for radiation dose estimations is the mathematical Monte-Carlo-Simulation that provides detailed dose distribution for each individual. The knowledge from these monitoring techniques is used to establish methods for optimization of radiation dose and image quality. Studies evaluate the performance of modern technological developments for modulation of the x-ray spectra (organ based tube current modulation, tube voltage adaptation, spectral shaping, dual energy), for rapid examinations (high-pitch), for image reconstruction (iterative reconstructions, metal artifact reduction) and post-processing (dual energy techniques, anatomic landmark detection). Moreover, the potential protective effect of radical forming agents on DSB-induction is evaluated in vivo and in vitro.

Functional and metabolic MRI
Pt: Prof. Dr. M. Uder, Prof. Dr. R. Janka, PD Dr. M. Hammon, Prof. Dr. A. Cavallaro, Prof. Dr. F. Laun, Prof. Dr. A. Nagel
With sodium MRI, we are able to measure the sodium concentration in tissue non-invasively. Research focuses lie on its further technical development, its absolute calibration, and the evaluation of different physiologic and pathophysiologic conditions.
Diffusion weighted imaging (DWI) visualizes the diffusion of free water molecules in tissue. The physiological amount of diffusion is disturbed in tissue with higher cell density particularly in tumors. The use of DWI develops continuously adding pivotal information as third pillar of MR imaging besides morphology and contrast enhancement characteristics.
In MRI, perfusion measurements without the use of contrast material are possible. For that purpose, the inflowing (arterial) spins are labeled magnetically and their concentration in the organ of interest can be measured as signal intensity. Our research focuses on determining renal perfusion.

Interventional radiology
Pt: Prof. Dr. R. Wüst, Prof. Dr. M. Uder, Prof. Dr. R. Janka
Clinical studies are performed in cooperation with the departments of Surgery, Nuclear Medicine, Medicine 1, Medicine 4 and the divisions of Vascular Surgery and Nephropathology. Research foci include the establishment of endovascular radiofrequency ablation of sympathetic nerve fibers in renal arteries of patients with resistant hypertension and of selective internal radiotherapy and CT-guided tumor ablation techniques (irreversible electroproporation, radiofrequency, and microwave). In patients with contraindication to the standard percutaneous biopsy of kidney transplants, an alternative transvenous biopsy procedure via a transfemoral approach is established.

Cardiovascular imaging
Pt: PD Dr. M. May, Prof. Dr. R. Janka, PD Dr. M. Hammon, Prof. Dr. A. Cavallaro, Prof. Dr. F. Laun, Prof. Dr. A. Nagel
Close cooperation exists with the departments of Medicine 2 and of Pediatrics and Adolescent Medicine, the Institute of Medical Physics, and the divisions of Pediatric Cardiology and Pediatric Cardiac Surgery.
Studies are performed to evaluate CT and MR for morphological and functional imaging of apparent coronary artery disease and to evaluate the potential of coronary CT-angiography in early diagnosis of coronary artery sclerosis in line with the Leading Edge Cluster. Furthermore, longitudinal studies to assess physiologic myocardial adaptation in recreational and professional athletes using MRI and to diagnose congenital heart disease with CT and MRI are conducted.

Breast imaging and gynecological radiology
Pt: Prof. Dr. R. Schulz-Wendtland, PD Dr. E. Wenkel, Prof. Dr. R. Janka, Prof. Dr. F. Laun
In the breast imaging group, new methods for digital mammography are developed in cooperation with different medical systems manufacturers. On the basis of substantial experimental and clinical studies, their work includes development, implementation, and comparison of different digital mammography and ultrasound systems, including tomosynthesis, 3D and CAD (fusion- and hybrid systems). In addition, detection and volumetric analysis of tumors by mammography, (automated) ultrasound and the further characterization of breast masses by sonographic elastography are under investigation. Another main focus lies in breast MRI...
Information technology in radiology
PI: Prof. Dr. A. Cavallaro, PD Dr. M. Hammon, Dr. P. Dankerl, Dr. H. Seuß
Aims of this group include the development of novel and intelligent medical databases as performed within the collaborative project 'Clinical Data Intelligence' of the BMWI (Federal Ministry for Economic Affairs and Energy). Important tasks of our group are the optimization of automatic algorithms for segmentation and characterization (e.g. for breast cancer) as well as the inclusion of clinical data and information from the genome. Modern mathematical algorithms such as ‘deep learning’ or ‘ANN’ together with methods of pattern recognition from radiological data may help to obtain disease-specific parameters. By connecting data from the electronic health record and genome analysis we furthermore assess the impact on diagnosis and image interpretation for therapeutic management of patients. For the resulting big amount of relevant data, our research group optimizes the automation of information extraction and data anonymization.

Experimental radiology and small animal imaging
PI: Prof. Dr. T. Bäuerle, Dr. C. Gillmann, Dr. S. Ellmann
Dedicated preclinical scanners are available for the imaging modalities MRT, CT, PET, SPECT, ultrasound and optical imaging for in- and ex vivo studies. Focus of this research group is the establishment and optimization of innovative multimodal imaging techniques. Thereby information on the molecular, functional, and morphological level are acquired noninvasively and correlated with the underlying pathology or pathophysiology. Examples include the investigation of experimental bone metastases, muscle inflammation models (arthritis, asthma and colitis), and surgically removed tissue (hippocampus). Major aim is the translation of these methods into clinical application.

Musculoskeletal imaging research
PI: PD Dr. F. Roemer, Prof. Dr. T. Bäuerle
The focus of musculo-skeletal is the characterization of osteoarthritis by magnetic resonance imaging. This includes tissue evaluation in osteoarthritis through comprehensive joint assessment and the development and validation of quantitative and semiquantitative evaluation tools for application in cross-sectional and longitudinal fashion. One of the major research interests is the application of such MRI-based instruments to better understand the natural history of degenerative joint diseases and particularly focus on prediction models to isolate patients at high risk for disease incidence and progression. A close collaboration with the Department of Radiology at Boston University School of Medicine is on-going and has enabled active involvement in the largest on-going epidemiologic osteoarthritis studies including the Multi-center Osteoarthritis Study (MOST) and the Osteoarthritis Initiative (OAI), both with several thousand participants that are being followed over many years. The Institute is participating member of the recently launched Applied Public-Private Research enabling OsteoArthritis Clinical Headway (APPROACH) consortium of the European Commission’s Innovative Medicines Initiative.

MR-physics
PI: Prof. Dr. F. Laun, Prof. Dr. A. Nagel
The focus of the MR physics group is on the development of new image acquisition, image reconstruction and post-processing techniques for magnetic resonance imaging. These techniques are evaluated in close collaboration by physicists and clinicians. The aim is to provide improved clinical radiological diagnostics. Among others, techniques are developed to acquire in vivo images of the sodium (23Na), potassium (31P), chloride (35Cl), or phosphorous (31P) distribution. These nuclei play an important role in many physiological processes. For example, the 23Na-, 31P- and 35Cl-concentrations are closely related to the physiological status of the cells. An additional focus is on the development of new methods to measure susceptibility and diffusion of water molecules in vivo. The measurement of diffusion coefficients provides information about the tissue structure and integrity. Clinical applications of diffusion-weighted imaging are, for example, the diagnosis of ischemic stroke and prostate carcinomas.

Selected Publications

International Cooperations
Prof. A. Bogdano, PhD, University of Massachusetts, Worcester: USA
Prof. D.R. Enzmann, MD, UCLA, Los Angeles: USA
Prof. W.E. Fah, PhD, University of Wisconsin-Madison, Madison: USA
Prof. R. Frobell, Lund University, Lund: Sweden
Prof. A. Guermazi, MD, PhD, Boston University School of Medicine, Boston: USA

Teaching
Besides the standard lectures and practical courses, innovative clinically orientated courses are regularly offered including interactive discussions of clinical cases. In these courses the students are taught a much more analytic and clinical rather than a systematic approach towards the interpretation of radiologic images. A new online course was established for students to prepare effectively for the state examination. Staff of the degree program Medical Radiology can always perform clinical electives or internships at our Institute. Students striving for a doctor’s degree are supervised closely when writing their experimental or clinical thesis. Furthermore, the Institute of Radiology participates in degree programs Medical Process Management and Molecular Medicine (Faculty of Medicine) as well as Medical Technology (Faculty of Engineering).