Institute of Radiology

Chair of Diagnostic and Interventional Radiology

Address
Maximiliansplatz 3
91054 Erlangen
Phone: +49 9131 8536065
Fax: +49 9131 8536068
www.radiologie.uk-erlangen.de

Director
Prof. Dr. med. Michael Uder

Contact
Prof. Dr. med. Tobias Bäuerle
Phone: +49 9131 8545521
Fax: +49 9131 8536068
tobias.baeuerle@uk-erlangen.de

Research focus
- Optimization of radiation dose and image quality in computed tomography
- 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 Chair

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

Special structural feature
Four locations (departments of Internal Medicine, Surgery, Gynecology and Obstetrics, Pediatrics and Adolescent Medicine)

Research

Scientific focus of the Institute of Radiology 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 preclinical studies are well-established in our scientific activities.

Optimization of radiation dose and image quality in computed tomography

PI: PD Dr. M. May, Dr. M. Brand, PD Dr. W. Wüst, Prof. Dr. M. Uder

CT is the major contributor to overall medical x-ray exposition. Radiation induced DNA-doublestrand-breaks (DSB) can be detected by immunofluorescence microscopy. Recent studies have shown a strong correlation between DSB levels and the dose deposed 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).

Interventional radiology

PI: PD Dr. A. Schmid, PD Dr. W. 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, of endovascular therapies in dysfunction of av-fistulas, of selective internal radiotherapy and CT-guided tumor ablation techniques (irreversible electroporation, 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

PD Dr. W. Wüst, PD Dr. M. May, Dr. C. Treutlein, Dr. R. Heiss, Dr. J. Roth, Prof. Dr. M. Uder

One of the main limitations of cardiac MRI are long examination times. Especially for older, ill patients an examination with multiple breath-holds is very demanding. In the last couple of years, real time sequences were developed to speed up the examination time. Focus of studies in children and adults is the reproducibility and comparability to the standard sequence. Real time imaging not only shortens examination times, but also gives the opportunity to examine patients with arrhythmia to improve image quality compared to the standard sequence. Another development in the last couple of years are sequences for quantitatively characterization of cardiac tissue. One of the main drawbacks of this new technique is that published values are highly dependent on scanner and sequence type, thus leading to low comparability. Up to now, published values cannot be compared to each other and further studies are mandatory to increase the clinical acceptance of this new technique.

Breast imaging and gynecological radiology

PI: Prof. Dr. R. Schulz-Wendtland, Prof. Dr. E. Wenkel, Prof. Dr. R. Janka, Prof. Dr. F. Laun, Dr. S. Ohlmeyer

In this group, new methods for digital mammography are developed in cooperation with different medical systems manufacturers. Based on substantial experimental and clinical studies, the 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 focus lies in breast MRI and the development of new MRI sequences for better differentiation between malignant and benign breast disease at 1.5T, 3T and – in cooperation with the unit of experimental imaging – at 7T.

Finally, we are cooperating with the Institute of Medical Physics to develop a breast CT scanner.

Information technology in radiology

PI: Prof. Dr. A. Cavallaro, PD Dr. M. Hammon, Dr. P. Dankerl, Dr. H. Seuß

The joint project Clinical Data Intelligence of the Federal Ministry of Economics and Technology was successfully completed. By linking the con-

tents from the electronic patient file and the gene analysis, possible changes in the diagnosis determination and/or image interpretation and the influence on the therapy management were examined. The working group optimized the automation of structured data extraction and anonymization for the large volumes of data that were required. The development of intelligent medical databases will be continued. Further research on modern algorithms, such as deep learning in connection with pattern recognition from radiological images, will be conducted. New approaches for direct integration of modalities (e.g. computed tomography) are being piloted.

Experimental radiology and small animal imaging

PI: Prof. Dr. T. Bäuerle, Dr. C. Gillmann, Dr. S. Ellmann

Focus of this research group is the establishment and optimization of innovative multimodal imaging techniques (MRI, CT, PET, SPECT, ultrasound, and optical imaging), particularly within interdisciplinary research consortia (e.g. projects within DFG funded programs). Thereby information on the molecular, functional, and morphologic level are acquired noninvasively and correlated with the underlying pathology or pathophysiology. In cooperation with the Chair of Pattern Recognition, we apply automatic segmentation solutions to determine quantitative image parameters. These parameters are integrated in machine learning algorithms for increasing diagnostic accuracy within larger collectives (radiomics). Examples include the investigation of experimental bone metastases, murine inflammation models (arthritis, asthma, and colitis). Major aim is the translation of these methods into clinical application, e.g. the discrimination of unclear breast and prostate lesions.

Musculoskeletal imaging research

PI: Prof. Dr. F. Roemer, Prof. Dr. T. Bäuerle, PD Dr. T. Bayer, Dr. R. Heiss

The focus of this group is the characterization of osteoarthritis by MRI. One of the major research interests is the application of such MRI-based imaging tools 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. Another research focus is the development of compositional measurement methods for the assessment of cartilage, subchondral bone, and synovium at ultra-high field MRI (7T).

A close collaboration with the Department of Radiology at Boston University School of Medicine is ongoing and has enabled active involvement in the largest on-going epidemiologic osteoarthritis studies including the Multicenter Osteoarthritis Study (MOST) and the Osteoarthritis Initiative (OAI), both with several thousand participants that are being followed over many years. The Institute is a 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

The focus of this group is on the development of new image acquisition, image reconstruction, and post-processing techniques for MRI. 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)- and potassium (39K)-distribution. These nuclei play an important role in many physiological processes. For example, the 23Na- and 39K-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 diagnostics of ischemic stroke and prostate carcinomas. In addition, high-gradient methods (e.g. dedicated breast gradients, $G > 1$ T/m) are being developed in a DFG-funded project to determine tissue microstructure. In order to enable a quantitative evaluation, suitable validation and reference objects, so-called phantoms, are also being developed. There are numerous national (e.g. German ultra-high field imaging (GUFI) network, DKFZ Heidelberg, MDC Berlin) and international collaborations (including Harvard Medical School, Boston, and Institut Myologie, Paris). In addition, various projects involve a very close cooperation with Siemens Healthineers.

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. Students of the degree program Medicine 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). In addition, a joint seminar „Physics in Medicine" is offered in cooperation with the Department of Physics (Faculty of Sciences).

Selected publications

Czegley C, Gillmann C, Seyler L, Schauer C, Naschberger E, Uder M, Schett G, Bäuerle T, Hoffmann M. A chronic enthesitis model with inflammation an new bone formation characterized by multimodal imaging. Dis Model Mech. 2018 Aug 30;11(9). pii: dmm03404

Gast LV, Gerhalter T, Hensel B, Uder M, Nagel AM. Double quantum filtered 23 Na MRI with magic angle excitation of human skeletal muscle in the presence of B0 and B1 inhomogeneities. NMR Biomed. 2018 31(12):e4010

Heiss R, Wiesmueller M, Treutlein C, Seuss H, Uder M, May M, Wuest W. Cardiac T2 star mapping: standardized inline analysis of long and short axis at three identical 1.5 T MRI scanners. Int J Cardiovasc Imaging. 2018 Nov 21

Regus S, Lang W, Heinz M, Rother U, Meyer A, Almási-Sperling V, Uder M, Schmid A. Time-extended local rtPA infiltration for acutely thrombosed hemodialysis fistulas. Hemodial Int. 2018 22:31-36

Roemer FW, Kwoh CK, Fujii T, Hannon MJ, Boudreau RM, Hunter DJ, Eckstein F, John MR, Guermazi A. From Early Radiographic Knee Osteoarthritis to Joint Arthroplasty: Determinants of Structural Progression and Symptoms. Arthritis Care Res (Hoboken). 2018;70:1778-1786

Schellhaas B, Hammon M, Strobel D, Pfeifer L, Kielisch C, Goertz RS, Cavallaro A, Janka R, Neurath MF, Uder M, Seuss H. Interobserver and intermodality agreement of standardized algorithms for non-invasive diagnosis of hepatocellular carcinoma in high-risk patients: CEUS-LI-RADS versus MRI-LI-RADS. Eur Radiol. 2018 28:4254-4264

International cooperations

Prof. A. Bogdanov, PhD, University of Massachusetts, Worcester: USA

Prof. S. Trattnig, MD, Universitätsklinikum Wien, Vienna: Austria

Prof. A. Guermazi, MD, PhD, Boston University School of Medicine, Boston: USA

Prof. Y. Rathi, PhD, Harvard Medical School, Boston: USA

Prof. J. Titze, MD, Duke National University, Singapore: Singapore