UNIVERSITY HOSPITAL

Institute of Radiology

Chair of Diagnostic and Interventional Radiology

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Research focus
- Cardiovascular imaging
- Artificial intelligence and Big data
- Translational imaging in tumor and inflammation
- .Medical engineering
- Breast imaging and gynecological radiology
- Musculoskeletal imaging research
- MR-physics

Structure of the Chair

Professorships: 4
Personnel: 162
- Doctors (of Medicine): 52
- Scientists: 5 (thereof funded externally: 5)
- Graduate students: 11

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.

Cardiovascular imaging
PI: PD Dr. A. Schmid, PD Dr. M. May, Dr. R. Heiss, Dr. K. Hellwig, Dr. C. Treutlein, Dr. M. Wiesmüller, Dr. M. Zeilinger

One of the main limitations of cardiac MRI are long examination times. Especially for older, ill patients an examination with multiple breathholds 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.

Artificial intelligence and Big data
PI: PD Dr. S. Ellmann, PD Dr. S. Bickelhaupt, Prof. Dr. M. Dietzel, Dr. K. Hellwig, Dr. L. Kapsner
As a result of technological progress, artificial intelligence (AI) and machine learning methods are increasingly being used in diagnostic medical imaging. These methods facilitate the extraction of patterns and correlations in multisectional medical data sources and thereby derive new translational approaches for improving radiological diagnostics as well as for personalizing medical clinical care. Ongoing development and research of these digital health technologies is therefore one of the central tasks of translational clinical research in the 21st century. The working group "Artificial Intelligence and Big Data" designs and develops new research projects in close interdisciplinary cooperation with the medical theoretical subjects and computer science. The aim is to use machine learning and artificial intelligence methods to further improve diagnosis, therapy control and prognosis for patients and to further support the development of personalized precision medicine. The potential of the technology has been demonstrated in studies addressing breast and prostate imaging (see publication list), and is also being evaluated in other medical applications such as rheumatological diseases in interdisciplinary research projects.

Translational imaging in tumor and inflammation
PI: Prof. Dr. T. Bäuerle, PD Dr. S. Ellmann, Dr. K. Hellwig, Dr. V. Popp, Dr. C. Treutlein
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 CRC 1181 Checkpoint of resolution and SPP 2084 µbone). 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.

Medical engineering
PI: PD Dr. M. May, Dr. M. Wiesmüller, Dr. M. Kopp, Dr. R. Heiss, Dr. M. Wetzl, Dr. M. Schöniger, F. Geissler, S. Daniel, T. Rüttinger, M. Bachl
Computed tomography (CT) is a widespread, accessible diagnostic method. Contemporary scanner technology is capable to provide three-dimensional data with high image resolution. Such images are often crucial to make a clinical diagnosis. However, the concomitant radiation dose must be monitored as the „linear-no-threshold“ model of radiadion induced cancerogenes implies that even minor radiation exposure lead to increased stochastic cancer risk. Consequently, in the past few years we focused our efforts on optimized and personalized examination protocols as well as increased dose efficiency. For each scan protocol the image quality is supposed to remain optimal under consideration of the individual CT indication. Future projects will focus on the clinical evaulation of innovative, articial intelligence-based algorithms (e.g. automated intracranial hemorrhage detection) and intelligent examination protocols.

Breast imaging and gynecological radiology
PI: Prof. Dr. E. Wenkel, PD Dr. S. Bickelhaupt, Prof. Dr. M. Dietzel, Prof. Dr. R. Janka, Prof. Dr. F. Laun, Dr. L. Kapsner, Dr. S. Ohlmeyer, Prof. Dr. R. Schulz-Wendtland, Dr. M. Wetzl
Breast cancer is the most common malignancy in women and imaging plays a central role at all stages of its therapy and prevention. The primary objective of our work is early, minimally invasive, and highly accurate diagnosis. In addition, we investigate imaging biosignatures of breast cancers applying radiomics, artificial intelligence and functional imaging techniques. We collaborate across all relevant disciplines with our local, national and international partners. We drive technical developments in collaboration with leading medical technology companies. Here, the technical optimization of established (digital mammography, tomosynthesis, magnetic resonance imaging, ultrasound) and the evaluation of new methods (dedicated breast computed tomography, microwave imaging etc.) are within the main focus of our activities. A comprehensive research infrastructure including six MRI scanners from 0.55T to 7T field strength and a dedicated breast computed tomography scanner is at our disposal.

Musculoskeletal imaging research
PI: Prof. Dr. F. Roemer, Prof. Dr. T. Bäuerle, Dr. R. Heiss

The focus of musculo-skeletal research at the Department of Radiology is the characterization of osteoarthritis, muscle pathologies and sports-related disorders by MRI. 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. Further, the role of post-traumatic changes and later osteoarthritis development has been a topic of on-going research, which includes multi-dimensional assessment of anterior cruciate ligament injury and its sequelae. The group has been involved in large analyses of imaging data of the Rio 2016 Olympics focusing on joint injuries. A close collaboration with the Department of Radiology at Boston University School of Medicine is on-going where Prof. Roemer holds a position as Adjunct Professor of Radiology and as Co-Director of the Quantitative Imaging Center (QIC), a research group addressing complementary research questions. The department is partner of the APPROACH consortium, which received a 14 million Euro grant from the European Commission's Innovative Medicines Initiative (IMI). An additional focus of the group is MRI of muscle pathologies and interventions including application of advanced metabolic imaging at 7T MRI. Currently the group is leading a multi-center effort applying 7T MRI for assessment of wrist disorders using morphologic and compositional imaging funded by the German Roentgen Society (DRG). Dr. Roemer is Editor-in-Chief of Osteoarthritis Imaging, The official Journal of the International Society of Osteoarthritis Imaging (ISOAI).

MR-physics

PI: Prof. Dr. A. Nagel, Prof. Dr. F. Laun

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 breast cancer. In addition, new methods are developed to make 7 T MRI applicable in a broad clinical setting. In or-der 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 Institute of Cancer Research, London, University of Glasgow, University of Minnesota and Institute of Myology, 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

Ellmann S, Schlicht M, Dietzel M, Janka R, Hammon M, Saake M, Ganslandt T, Hartmann A, Kunath F, Wullich B, Uder M, Bäuerle T (2020) Computer-Aided Diagnosis in Multiparametric MRI of the Prostate: An Open-Access Online Tool for Lesion Classification with High Accuracy. Cancers 12(9):2366.

Geissler F, Heiß R, Kopp M, Wiesmüller M, Saake M, Wuest W, Wimmer A, Prell V, Uder M, May MS (2020) Personalized computed tomography - Automated estimation of height and weight of a simulated digital twin using a 3D camera and artificial intelligence. Rofo. 2020 Nov 3. doi: 10.1055/a-1253-8558.

Heiss R, Guermazi A, Jarraya M, Engebretsen L, Hotfiel T, Parva P, Roemer FW (2019) Prevalence of MRI-Detected Ankle Injuries in Athletes in the Rio de Janeiro 2016 Summer Olympics. Acad Radiol 26(12):1605-1617.

Kopp M, Loewe T, Wuest W, Brand M, Wetzl M, Nitsch W, Schmidt D, Beck M, Schmidt B, Uder M, May M (2020) Individual Calculation of Effective Dose and Risk of Malignancy Based on Monte Carlo Simulations after Whole Body Computed Tomography. Sci Rep. 10(1):9475. doi: 10.1038/s41598-020-66366-2.

Ohlmeyer S, Laun FB, Palm T, Janka R, Weiland E, Uder M, Wenkel E (2019) Simultaneous Multislice Echo Planar Imaging for Accelerated Diffusion-Weighted Imaging of Malignant and Benign Breast Lesions. Investigative Radiology 54: 524–530.

Saake M, Schmidle A, Kopp M, Hanspach J, Hepp T, Laun FB, Nagel AM, Dörfler, A, Uder M, Bäuerle T (2019) MRI brain signal intensity and relaxation times in individuals with prior exposure to gadobutrol. Radiology 290 (3): 659-668.

Treutlein C, Bäuerle T, Nagel AM, Guermazi A, Kleyer A, Simon D, Schett G, Hepp T, Uder M, Roemer FW (2020) Comprehensive assessment of knee joint synovitis at 7 T MRI using contrast-enhanced and non-enhanced sequences. BMC Musculoskelet Disord. 21(1):116.

International cooperations

Prof. Pascal Baltzer, Medical University of Vienna, Austria

Prof. Ali Guermazi, Boston University School of Medicine, Boston, MA, USA

Prof. Guillaume Madelin, New York University School of Medicine, New York, USA

Prof. Greg Metzger, University of Minnesota, USA

Prof. David Porter, University of Glasgow, Scotland

Prof. Jens Titze, Duke National University of Singapore, Singapore

Prof. Siegfried Trattnig, Medical University of Vienna, Austria

Prof. Maxim Zaitsev, Medical University of Vienna, Austria