1.) Research: major achievements

.1 Parameter selective MR-microscopy on a whole body MR-system

On clinical MR-scanners usually smallest voxel volumes of about 0.5 x 0.5 x 3 \( \text{mm}^3 \) are achieved. Within an FWF-project a MR-measuring device (microscopy-tool) as additional component for a 3T-whole body-MR-scanner was set-up (fig. 1a), by which a pixel size of microscopic order (d < 0.1 mm) is obtained. We were not only able to achieve the lowest voxel sizes on a whole body scanner operated at 3T, demonstrated yet, but could also proof quantitatively a spatial resolution of 32 µm using a specifically for MR-microscopy designed grid structure (phantom) [Berg 2001b] by microlithography at the institute for solid state electronics. This phantom (fig. 1b) has been patented [Berg 1999]. The potential of MR-microscopy combined with parameter mapping (T1, T2, diffusivity) with reference to contrast optimized visualization of pathologic degenerations in tissue has been demonstrated for atherosclerotic plaques (fig. 1c and d) [Berg 2003c] and an enzymatic degradation of cartilage as an arthritis model [Berg 2003b].

.2 MRI-based polymer dosimetry for precise radiation therapy

The new developments in radiation therapy for cancer treatment: Intensity modulated radiotherapy with micro-multi-leaf collimation (IMRT), brachytherapy (BT) and proton irradiation are mainly related to the improvement in conformity and smaller margins, demanding for 3-dimensional dosimetric methods at higher spatial resolution. In the frame of this work we proposed a theoretical construct for addressing the spatial resolution in different dose imaging systems, i.e. the Dose Modulation Transfer (DMTF) approach, designed an experimental realization of this concept using a dose modulation grid and performed quantitative comparisons between two dosimetric imaging systems: MRI-based polymer gel dosimetry and film dosimetry [Berg 2004a]. By separating dose differences at 280 µm distance we showed the highest spatial resolutions in MR-based dosimetric imaging yet and
demonstrated that this tissue equivalent, 3D-dosimetric imaging method might be even a competitor to clinical film-scanner systems concerning spatial resolution, the domain of film dosimetry. As an application the 3D-dose distribution of an electron beam of 2 mm diameter is measured and a coronal projection shown in fig. 2a. Recently we [Bayreder 2004, 2006] were also able to manufacture normoxic-polymer gels in our own laboratory, which simplifies the evaluation and applications significantly. Within a cooperation with Hahn-Meitner-Institut, Berlin we performed 3D-dosimetric measurements on the dose distribution of a 68 MeV proton beam used for eye tumor therapy. LET-quenching of the dose response in the Bragg-peak has been corrected for. Thus we achieved the first low noise, high-resolution (Voxel volume < 0.1 mm$^3$) 3D-data sets (Mtx: 128 x 128 x 25) of a proton beam for heavy ion-therapy [Berg 2005] (fig. 2b and c).

![Fig. 2b](image) Depth dose curve for Markus ionisation chamber and THPC polymer gel. The dose curve considering quench correction is indicated by the blue line.

![Fig. 2c](image) Quench corrected dose image of the central slice taken from the dose 3D data set. Note the excellent SNR at a voxel volume of 0.063 mm$^3$.

.3 MR-imaging of hard tissue and composites as biocompatible materials

MRI is known for offering high spatial resolution and contrast in soft tissue. Solid type materials in the human body as human dental tissue or polymer type implants give no active MR-signal due to their very short T2 relaxation time. Thus human teeth or polymer implants can only be visualized as hypointense foreground versus a bright background (fig. 3a). Their inner structure of semirigid tissue or implant material cannot be investigated. Using single-point-imaging (SPI) the first high resolution detailed 3D-images of the inner structure of the human tooth including caries regions [Berg 2002] (fig. 3b) and the delineation of the hardening process in composites used in conservative dentistry have been visualized by MRI on a whole body MR-scanner [Berg 2004b].

![Fig. 3a](image) MR-image of the human dentition by routine clinical MR. No inner structure within the tooth is observed.

![Fig. 3b](image) Multi-axial view of the 3D data set of a human tooth by MR-micro-imaging and SPI. The bright spot is indicating an area of tooth decay due to caries.

![Fig. 3c](image) MR-SPI-image of a hollow cube made of plastic. As a proof for the spatial resolution, achievable with such a pulse sequence, a 3D-grid type structure is visualized. The openings exhibit a diameter of 800 µm.

2.) References (selection)

[Testphantom zur Kontrolle der Abbildungsqualität in der hochortsauflosenden NMR-Bildgebung

High Resolution MR Imaging and Texture Analysis to differentiate osteoporotic Bone Structure
Proc. ISMRM, 8th scientific meeting, Denver/Colorado, USA, 01.-07.04.2000 (2000)

“High resolution polymer gel dosimetry by parameter selective MR-microimagining on a whole body scanner at 3 T”
Medical Physics, 28, No. 5, 833-843 (2001)
3.) Awards:

1.) European Society for Magnetic Resonance in Medicine and Biology (ESMRMB) 1999: Certificate of merit

High Resolution Dosimetry of a very small scaled Electron Beam by MR-based Polymer Dosimetry

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Animated data available for ESMRMB members via:

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