

Magnetic Resonance Imaging Contrast of Brain Tumors at 7 Tesla compared to 3 Tesla

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Introduction: It is well known that the magnetic field strength influences the effect of Gadolinium-based MR contrast agents.¹⁻⁴ The aim of the study was to compare the diagnostic efficacy of a Gadolinium-based MRI contrast agent in the evaluation of primary brain tumors at 7 Tesla MR scanner versus 3 Tesla.

Materials and Methods: Thirteen patients aged 25-69a (mean: 48a) with malignant primary brain tumors were examined on a whole body 7 Tesla MR scanner (Magnetom 7T, Siemens Healthcare Sector, Erlangen, Germany), using a 24-channel or an eight-channel transmit/receive head coil (Invivo, Pewaukee, Wisconsin, USA and RAPID, Würzburg, Germany), and on a 3.0 Tesla MR scanner (Magnetom Tim Trio, Siemens Medical Systems, Erlangen, Germany) using a 12-channel, receive-only head coil, supplied by the vendor. The study was approved by the local ethics committee, and written informed-consent was obtained from all patients prior to enrollment. All patients underwent an examination on the 7 Tesla scanner first. For the evaluation of the contrast agent behaviour, a sagittal 3D GRE sequence with magnetization preparation (MP-RAGE) after intravenous contrast agent administration was used at 7 Tesla, and at 3 Tesla. The parameters at 7 Tesla were as follows: TR 4660 msec, TE 3.55 msec, TI 1700 ms, Flip angle 9°, pixel bandwidth 180 Hz, matrix 320 x 307 pixel, FOV 230x230 mm, slice thickness 0.7 mm, acceleration factor 2, sequence duration 12:49. The contrast agent used was Gadobenate dimeglumine, in a dosage of 10 ml for each patient. Immediately after the examination at 7 Tesla, the patients were examined at a 3 Tesla scanner, with the following parameters: TR 2190 msec, TE 3.02 msec, TI 1300 ms, Flip angle 9°, pixel bandwidth 180 Hz, matrix 320 x 307 pixel, FOV 250x250 mm, slice thickness 0.7 mm, acceleration factor 2, sequence duration 11:16. Signal intensities were assessed by region of interest measurements in the lesion and the contralateral normal white and gray matter. The background noise was also assessed. The tumor-to-brain contrast on the enhanced images was calculated with the equation given below. For statistical analysis paired t-tests were used to compare the values for both field strengths. A p-value of <0.01 was considered statistically significant.

Tumor-to-brain contrast: $R_{L,B} [\%] = \frac{S_L - S_B}{S_B} \cdot 100$, with SL= signal intensity of the lesion, SB= signal intensity of the white matter.

Results: In 12/13 patients, the images were available for evaluation on both scanners. In one patient, due to a scanner defect at 7 Tesla, the post contrast images could only be assessed at 3 Tesla, and he was excluded from the study. The mean tumor-to-brain contrast after the administration of the contrast agent was markedly higher at 7 Tesla (91.4±43.7) than at 3 Tesla (37.3±32.8). The difference was statistically significantly different (p<0.001).

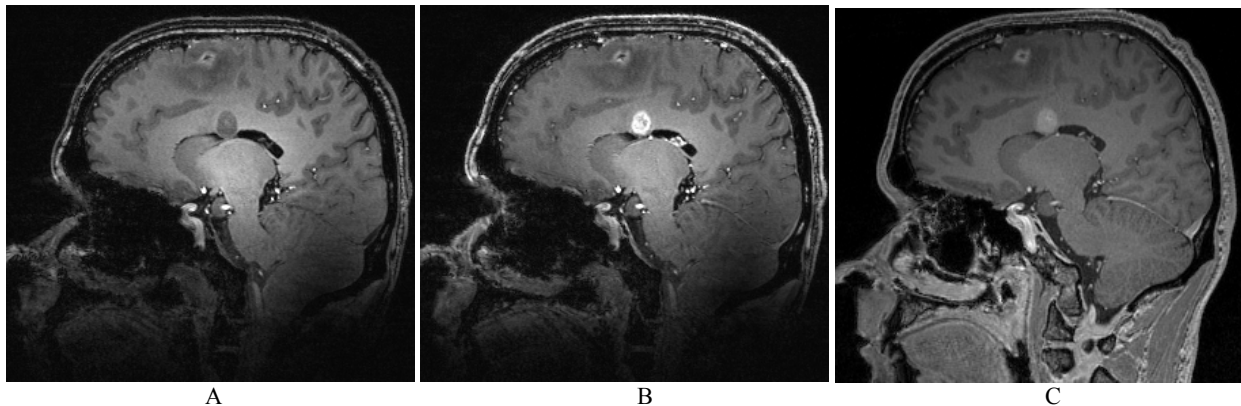


Figure 1. A 42-year-old male patient with a multifocal astrocytoma. The plain sagittal MP-RAGE scan at 7 Tesla (A) shows several lesions. One tumor that is hypointense to the white matter is directly adjacent to the lateral ventricle. After contrast administration the marked enhancement of this lesion leads to a higher tumor-to-brain contrast at 7 Tesla (B), than at 3 Tesla (C).

Discussion/Conclusion: It is well known that the effect of contrast agents is influenced by the magnetic field strength. The effect and behavior of contrast agents at different field strengths depends on the nuclear magnetic relaxation dispersion and the field-dependent relaxation of the tissue. The tumor-to-brain-contrast after gadolinium administration on the MP-RAGE scans was significantly higher at 7 Tesla (91.4) than at 3 Tesla (37.3). The improved contrast between the tumor and the surrounding brain 7 Tesla bears potential benefits: Further studies with larger patient numbers have to show whether it is possible to either reduce the dosage of the agent at 7 Tesla, without losing diagnostic information, or if it is advantageous to keep to standard doses of Gadolinium based contrast agents, and gain a better visibility of lesions with minor contrast enhancement.

References: [1].Chang et al. AJNR 1994;15:1413-1419. [2]. Noebauer-Huhmann et al. Invest Radiol 2002; 37:114-119. [3].Runge et al. Invest Radiol 2006;41: 244-248. [4].Wintersperger et al. Invest Radiol 2007;42: 558-563.