MRI contrast enhancement of brain tumors at 3 Tesla versus 1.5T

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Abstract
To compare the diagnostic efficacy of a standard dose of an MRI contrast agent in the evaluation of brain tumors using a high-field 3T MR unit versus a 1.5T MR unit. Sixteen patients with brain tumors were examined at both field strengths using identical axial T1-SE protocols and coronal 3D GRE with magnetization preparation (MP-RAGE) optimized for each field strength. Evaluation was performed quantitatively and by visual assessment. Tumor-to-brain-contrast after Gd administration using both T1-SE and GRE protocolls were significantly higher at 3T than at 1.5 Tesla (93.0 vs 72.1 and 97.5 vs.46.3 respectively).

Introduction:
Within the past few decades, contrast-enhanced MRI has become the method of choice for visualization of most abnormalities of the brain. The intravenous administration of gadolinium-DTPA for contrast-enhanced images has proved to be very valuable in the evaluation of primary brain tumors and metastases (1). Currently, clinical MR-scanners operating at a magnetic field of 3 Tesla are offered by all major manufacturers. The increasing availability of such instruments in the near future raises the question of whether higher field scanners will improve the clinical evaluation of intracranial tumors after administration of contrast agents.
The aim of our study to compare contrast enhancement on 3 Tesla MRI images with conventional 1.5 Tesla MRI images in the evaluation of primary brain tumors and metastases.

Materials and Methods:
Patients
Fifteen consecutive patients (11 men and 4 women, mean age: 57 years) with a known primary brain tumor or metastases were prospectively examined. The images were acquired on a 3 Tesla MR scanner Medspec 30/80 (Bruker; Ettlingen, Germany) with a maximum gradient strength of 45mT/m and on a 1.5 Tesla MR unit (Siemens Vision; Siemens Medical Systems, Erlangen, Germany) with a maximum gradient strength of 23mT/m.
All patients were examined in random order on both units before and after administration of contrast agent. The examinations were performed separately on both MR scanners with a time interval of at least three days. The contrast agent used in a standard dose (0.1 mmol/kg) was Gadodiamide, (Omniscan™, Nycomed-Amersham, Oslo, Norway). MR imaging protocol included axial T1-SE pre- and postcontrast on both scanners. Contrast-enhanced T1-weighted 3D-gradient echo sequence with magnetization preparation (MP-RAGE) was optimized for each magnetic field strength.
Qualitative assessment included the following: 1) the *visibility*; 2) the *delineation* of the lesion; 3) the "*contrast enhancement*" of the lesion 4) the "*gray-white differentiation*", and 5) the subjective overall "*diagnostic usefulness*" rated as 0 (non-existent) to 4 (excellent). Artifacts including motion, susceptibility, other artifacts (e.g., pulsation or ringing), and subjective image noise were graded as 1 (absent), 2 (mild), 3 (moderate), or 4 (severe).

Quantitative image assessment:
Numerical *tumor-to-brain-contrast after gadolinium administration* ($R_{L,B}$) defined as $R_{L,B}[\%]=\frac{S_L-S_B}{S_B}\cdot 100$.
Signal enhancement of the lesion (E_L) defined as $(E_L[\%]=\frac{S_L-S_{L0}}{S_{L0}}\cdot 100)$.
The statistical analysis included the paired t-test and the paired Wilcoxon signed rank test. For all tests, significance was set at $p < .05$.

Results
For lesion delineation and visibility, the ratings in the post-contrast series were not significantly different. The subjective impression of *contrast enhancement* of the lesion estimated in both sequences did not differ significantly with 3 Tesla vs. 1.5 Tesla .
The *gray-white differentiation* of T1-SE pre- and post-contrast series was significantly better with 1.5 Tesla than with 3 Tesla. *Overall diagnostic usefulness* was not significantly different for either of the sequences. Motion artifacts did not differ in any of the series with either scanner. Susceptibility and other artifacts (pulsation- and ringing-artifacts were observed) were subjectively higher at 3 Tesla than at 1.5 Tesla in all series.
Quantitative image assessment: On average, the *tumor-to-brain-contrast after gadolinium administration* ($R_{L,B}$) in MP-RAGE post-contrast sequences was significantly higher on the 3.0 T images than on the 1.5 Tesla ones (with p=0.036; mean difference =51.2. 95%; confidence interval, 4.4-98.1). The same was true for the T1-SE post-contrast scans (with p=0.028, mean difference =20.86. 95%; confidence interval, 2.86-38.87). The *signal enhancement for the lesion* (E_L), in the T1-SE scans was 11.2% higher at 3 Tesla compared to 1.5 Tesla. This difference was not statistically significant.

Discussion
In our study, we demonstrated that in postcontrast MP-RAGE, and even in post-contrast T1-SE not optimized for 3 Tesla, the contrast between the tumor and the surrounding normal brain is markedly higher at 3 Tesla compared to 1.5 Tesla. The observed increase in tumor-to-brain contrast is in accordance with studies at lower field strengths (2). Our results confirm the previous expectations (3) that although both the relaxation rate of the unenhanced tissue and the relaxivity of the contrast agent decrease with increasing field strength, it is not a proportional process. In summary, administration of a *gadolinium contrast agent* produces higher contrast between tumor and normal brain at 3 Tesla than at 1.5 Tesla.

References
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