Synthetic MP-RAGE anatomies with pure T1-weighting improve the detectability of brain tumors

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Introduction: MRI protocols for depicting tumor morphology and tumor location with respect to functionally important anatomical structures are in general based on T2-weighted or contrast agent (CA) enhanced T1-weighted imaging. Conventional non-enhanced T1-weighted anatomical imaging would provide improved anatomical details for precise tumor location. However, the tumor-to-background contrast is reduced in these images as the elevated T1 and proton density (PD) values in tumor tissue affect the signal inversely. Inhomogeneities of the radio frequency (RF) coils used may further mask tumor and edema outlines. The purpose of this work was (1) to overcome this problem by employing quantitative MRI (qMRI) techniques to create purely T1-weighted synthetic anatomies, which can be expected to yield improved tissue and tumor-to-background contrasts, (2) to compare the quality of conventional and synthetic anatomies, and (3) to investigate optical contrast and visibility of brain tumors and edema in the synthetic anatomies.

Materials and Methods: Conventional MP-RAGE anatomies and maps of T1, PD and RF coil bias were acquired in comparable and clinically feasible times on healthy subjects and tumour patients at 3T. Parameters of the MP-RAGE sequence [1] were: [TR, TE, TI, FA] = [2420ms, 3.68ms, 960ms, 9°], FoV=256x224x160m^3, 1mm isotropic resolution, duration 9:06 min. T1 and PD mapping was based on the VFA technique [2] using a FLASH-EPI hybrid readout and correcting for B1 inhomogeneities and insufficient spoiling of transverse magnetization [3]. FoV and resolution were chosen as above, TR/TE/FA1/FA2=16.4ms/6.7ms/4°/24°, duration 9:48 min. B1 mapping was performed as described in [4], FoV as above, isotropic resolution of 4 mm, duration 0:53 min. PD maps were calculated as proposed in [5]. Three synthetic MP-RAGE anatomies (T1-PD-weighting with and without RF-bias; pure T1-weighting) were calculated for healthy subjects and 32 brain tumor patients. Data were analyzed for signal-to-noise (SNR) and contrast-to-noise (CNR) ratios, for optical contrast (defined as signal difference between normal and pathological areas, divided by the mean signal) and visibility of tumors and edema.

Results: Healthy subjects: the T1-PD-weighted synthetic anatomies with RF-bias precisely match the conventional MP-RAGE anatomies, yielding about 80% of the SNR and CNR values of the conventional data. Pure T1-weighting yields lower SNR, but the same CNR due to increased optical contrasts. Brain tumor patients: synthetic anatomies with pure T1-weighting yield significant increases in optical contrast and improved visibility of tumor and edema as compared to anatomies reflecting conventional T1-contrasts (see Fig.1). Fig.2 shows for a tumor patient the synthetic anatomies with T1-PD weighting with/without RF coil bias (left/center) and with T1-weighting only (right). Pathological details have an increased contrast in the purely T1-weighted synthetic MP-RAGE (Fig.2, right, circle).

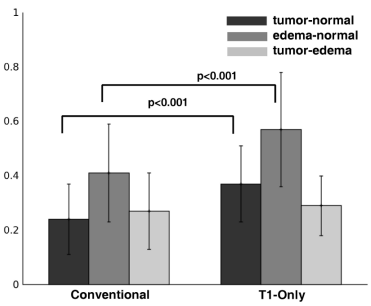

Fig. 1: Average optical contrast values for synthetic anatomies replicating the conventional MP-RAGE and purely T1-weighted synthetic anatomies. Shown are the contrasts between tumor and surrounding normal tissue, edema and surrounding normal tissue, and tumor and edema.

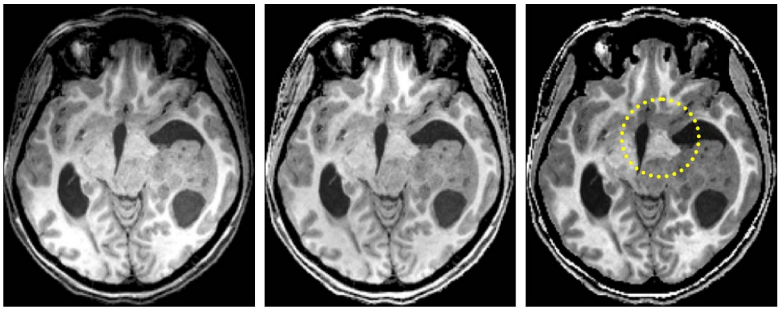

Fig. 2: Single slice of the synthetic MP-RAGE anatomies for one of the tumor patients. The left image replicates a standard acquired MP-RAGE (with T1-PD-weighting and RF bias); the center image is free of RF bias (T1-PD-weighting); the right image has pure T1-weighting, providing the best contrast for tumor delineation (circle).

Discussion and Conclusion: The data show that qMRI techniques allow the construction of synthetic MP-RAGE anatomies with SNR and CNR values similar to conventional MP-RAGE data acquired at a comparable acquisition time. Furthermore, qMRI techniques allow to remove the PD and RF coil bias, so purely T1-weighted anatomies can be constructed with 1mm isotropic resolution. It is shown that these purely T1-weighted anatomies considerably enhance optical contrast and visibility of brain tumors and edema and might therefore be of help in tumor diagnosis.

References:

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