Targeted B1+ Mapping using 3D Reduced Field-of-View Catalyzed Double-Angle Method

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Introduction:

For high field and quantitative MR imaging, it is often essential to measure *in vivo* B_1^+ field maps to correct signal intensity distribution. Fortunately, in many MRI applications, only a small portion of the field-of-view (FOV) may have important clinical interest. Therefore, only corresponding targeted portion of B_1^+ field information is needed. This study proposes a targeted B_1^+ mapping technique using 3D reduced FOV catalyzed double angle method (DAM). This method is based on 3D catalyzed DAM which allows a short TR for fast B_1^+ mapping by introducing catalyzation pulses at the end of each repetition cycle of DAM to drive the ratio of the ending longitudinal magnetizations (for the two different flip angle excitations) to unity [1]. This method employs an inner volume 3D turbo spin echo (TSE) sequence to limit the FOV and thereby to shorten imaging time [2].

Method: All experiments were performed using a 1.5T clinical MRI scanner (Siemens Magnetom Espree) with body coil transmitter. <u>*Sequence design:*</u> The 3D reduced FOV TSE catalyzed DAM sequence defines the inner volume by making a slab-selective excitation (slice direction) orthogonal to the slab refocused (phase-encoding direction) (**Fig. 1**). CPMG phase cycling scheme is used for TSE multi-echo acquisition. Crusher gradients alternating in sign and varying in amplitude in readout direction are applied to preserve only the primary echo pathway and eliminate stimulated echoes. The compensation and catalyzation chain pulses select the same region as the excitation pulse. RF spoiling and variant gradient spoiling are applied consecutively to each catalyzation pulse. <u>*Phantom studies:*</u> The accuracy of targeted B_1^+ mapping was validated in an $MgCl_2$ phantom (T1 = 300 ms) by comparing reduced FOV 3D TSE catalyzed DAM with full FOV method. Imaging parameters included: TE/Tb/Tc = 10.4/10.4/11 ms, excitation/refocusing/compensation flip angle (FA) = 60º/180º/120º and 120º/180º/60º, catalyzation chain FA = 90º, 3 catalyzation chain pulses, 550 Hz/pixel BW, ETL = 3, 100% slice over-sampling, Full FOV: TR = 2000 ms, 260×130×40 mm^3 FOV, 128×64×8 matrix; Reduced FOV: TR = 200 ms, 260×56×40 mm^3 FOV, 128×28×8 matrix. The measured FAs from reduced FOV method were compared with reference FA values obtained from full FOV method by calculating the percentage root-mean-squared (RMS) difference along a central line across the phantom. <u>*Volunteer studies:*</u> 3D targeted B_1^+ mapping method was further validated in brain and tested in abdomen of healthy volunteers. Additional *in vivo* parameters: Brain: Full FOV: TR = 1000 ms, 280×157×80 mm^3 FOV, 128×72×16 matrix; Reduced FOV: TR = 500 ms, 280×61×80 mm^3 FOV, 128×28×16 matrix, ETL = 3. The measured FAs from reduced FOV method were compared with a reference FA value from full FOV method by calculating the percentage RMS difference along a central line across the brain. Abdomen: Reduced FOV, TR = 280 ms, 380×83×40 mm^3 FOV, 128×28×8 matrix, 660 Hz/pixel BW, ETL = 5, GRAPPA acceleration factor 2, acquisition time: 16 sec.

Results: Full FOV and targeted B_1^+ maps and FA profiles along central line in the phantom were compared in **Fig. 2**. The results demonstrate excellent agreement between the two methods and the RMS different is < 0.4%. *In vivo* full FOV and targeted B_1^+ maps and FA profiles along central line in human brain were compared in **Fig. 3**. The results demonstrate excellent agreement between the two methods and the RMS difference is < 0.8%. **Fig. 4** shows representative abdominal 60º/120º reduced FOV TSE images and corresponding targeted B_1^+ map.

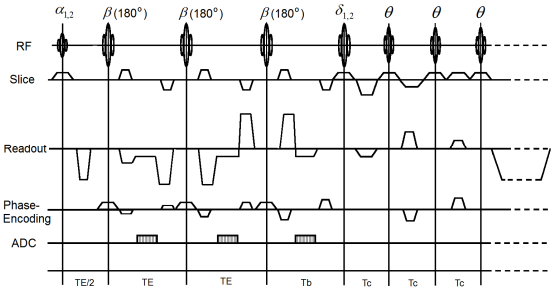

Fig. 1. Schematic diagram of 3D reduced FOV TSE catalyzed DAM sequence. α1,2: excitation pulse pair. β: refocusing pulse. δ1,2: compensation pulse pair. θ: catalyzation chain pulse. Tb: refocusing and compensation pulses spacing. Tc: catalyzation chain pulse spacing.

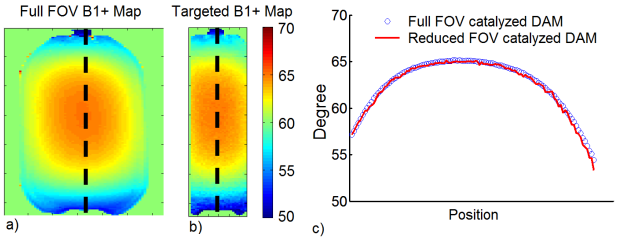

Fig. 2. a) The full FOV B_1^+ map of phantom acquired using full FOV catalyzed DAM with TR = 2000 ms, and b) targeted B_1^+ map of phantom acquired using reduced FOV catalyzed DAM with TR = 200 ms. c) FA profile along central line of phantom B_1^+ maps.

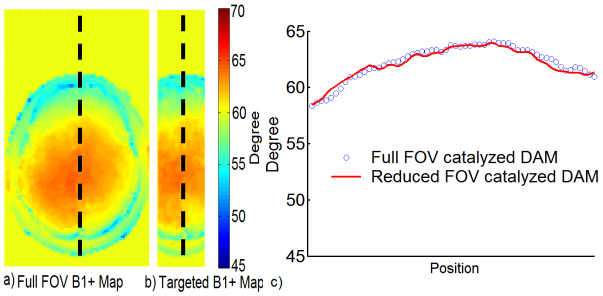

Fig. 3. a) The full FOV B_1^+ map of brain acquired using full FOV catalyzed DAM with TR = 1000 ms, and b) targeted B_1^+ map of brain acquired using reduced FOV catalyzed DAM with TR = 500 ms. c) FA profile along central line of brain B_1^+ maps.

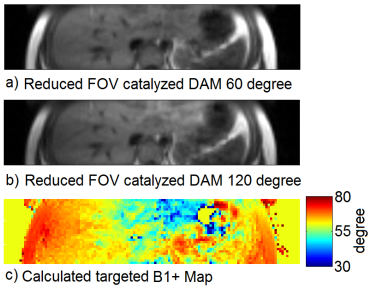

Fig. 4. Abdominal reduced FOV TSE images a) 60º b)120º c) corresponding targeted B_1^+ map

Conclusion: 3D reduced FOV TSE catalyzed DAM provides a rapid and accurate method for 3D targeted RF field mapping. Potential applications of the proposed 3D targeted B_1^+ mapping technique are the corrections of RF inhomogeneity in targeted quantitative applications, such as T1 mapping using variable FA method and T2 mapping using multiple-echo imaging for monitoring of targeted drug delivery, and quantitative transcatheter intra-arterial perfusion (TRIP)-MRI monitoring intra-procedural perfusion changes during interventions [3].

References: [1] Wang et al. ISMRM 2008 Abstract No.362 [2] Mitsouras et al. Mag Reson Med 2008 58:650–654 [3] Wang et al. Mag Reson Med 2008 60:970-975