Chemical Exchange Transfer Imaging: Efficient RACETE acquisition with Balanced Imaging Gradient Readout

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Introduction: We implemented RACETE[1] (Refocused acquisition of chemically exchanged transferred excitation) with a modified balanced SSFP-style readout[2], enabling efficient imaging of chemical exchange (CE). Unlike standard Chemical Exchange Saturation Transfer (CEST), RACETE generates a true positive contrast by refocusing prepared and subsequently exchanged magnetization. Compared to earlier implementations[3,4], the modified approach enables full image acquisition from a single preparation, substantially accelerating data acquisition.

Methods: RACETE employs a readout module adapted from the vendor's bSSFP sequence (Fig. 1 top). Preparation consists of 90° pulse pairs around an encoding gradient (G_S), repeated N_{ETM} times. The readout module following exchange pool preparation reuses G_S once to decode the stimulated echo signal after each α-pulse, and again after the data acquisition. The imaging block is repeated to fill k-space.
Measurements were performed on a 750 MHz spectrometer (Bruker, Germany) using salicylic acid in water. Parameters: N_{ETM} = 150, ω_1 = 9.1 ppm, matrix 128×64, FOV 20×20 mm², TE/TR = 3.5/7.0 ms, α = 50°. A FLASH-like method with similar settings was used for comparison, acquiring 128 FIDs post-preparation.

Results: Fig. 1 summarizes the results obtained with the newly developed RACETE sequence. It includes a comparison of the signal amplitudes from the first 128 readouts after a single preparation for both the RACETE method with balanced gradients and the FLASH-like spoiled approach. The figure also shows a stack of ten consecutively acquired RACETE images after a single preparation, enabling $T_{1,water}$ evaluation. Total acquisition time for this image series was 8 s, including 2 s for the preparation module.

Discussion: The modified RACETE maintains the true positive CE-contrast, while increasing the efficiency. Imaging gradients are fully rebalanced in each TR, the encoding/decoding gradients G_S are not. This ensures that the non-exchanged, non-encoded water signal is not refocused during any of the acquisitions, preventing contamination of the RACETE contrast. Simultaneously, the additional refocusing enhances signal by refocusing each STE, increasing SNR and permitting larger flip angles than in a purely FLASH-like approach.
These improvements support in vivo applicability: RACETE images can be acquired rapidly, and inherent $T_{1,water}$-evaluation can be used to eliminate unwanted $T_{1,water}$-influences from chemical exchange contrast.

References:
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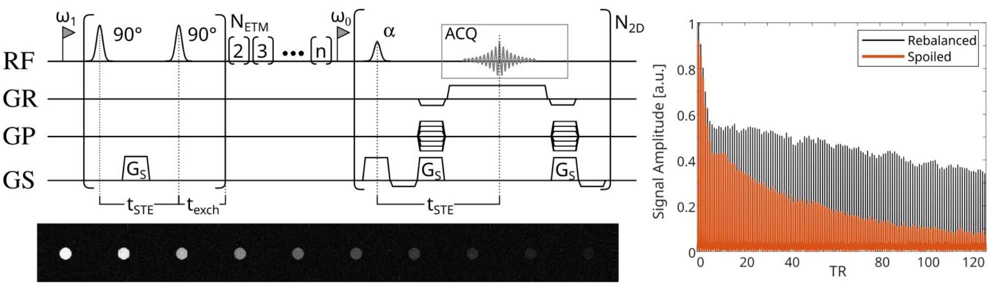

Figure 1: Left: Simplified sequence diagram, Right: Comparison of 128 spoiled and balanced readouts. Bottom left: Images acquired after single preparation.