Improved Background Suppression for 3D-MRCP using T2-Prep

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MR Cholangiopancreatography (MRCP) is a technique for visualizing the biliary ducts, pancreatic duct, and gall bladder to assess dilation and blockage caused by stones, masses, or inflammatory changes. Typically, 2D RARE sequences (a.k.a. SSFSE) are used with very long echo times that generate hydrographic (fluid only) images. 3D driven-equilibrium RARE sequences (a.k.a. 3D-FRFSE) have also been developed for hydrographic MRCP imaging, improving SNR and enabling thinner slices [1].

While "effective" echo times in excess of 400ms should provide excellent suppression of blood, fat, and soft tissue, residual signal, often in the form of high-frequency artifact, is often observed, obscuring fine anatomic detail. Two mechanisms may be responsible. First, due to B0 and B1 inhomogeneities, fat saturation pulses incompletely suppress fat magnetization. Because the refocusing RF pulses are very closely spaced, unsuppressed fat is slow to decay due to coherence transfer via isotropic mixing [2]. Second, due to the small size of blood vessels and the relatively long T2 of blood, blood vessels contribute significant high spatial frequency energy [3]. Edges of the blood vessels therefore appear as bright structures with ringing, contaminating the MRCP.

In this study, we demonstrate that the application of a T2-Prep pulse sequence module [4] improves background suppression, particularly for fat and blood, and increases conspicuity of the fluid filled biliary and pancreatic structures that are the target of an MRCP study.

Methods

A 3D-FRFSE pulse sequence was implemented that acquired all in-plane phase (y) encodes (PEs) in a linear order for a particular slice/depth (z) encode each repetition, requiring as many repetitions as prescribed slices. In the baseline case, FSE excitation occurred immediately after a fat-saturation pulse segment and the phase-encoded FSE readout began with the first echo. In order to reduce high frequency signal from short and moderate T2 materials, two variations were tested. In the first variation of the sequence, a number of unencoded "dummy" echoes (~30) were generated prior to beginning the phase-encoded readout, delaying acquisition by 150ms after excitation. In the second variation of the sequence, a 150ms T2-prep segment utilizing two refocusing pulses was inserted between the fat-saturation pulse and the FSE excitation. The active portion of the pulse sequence was therefore extended by 150ms, but the FSE readout was equivalent to the baseline case. TR was fixed for all cases.

A point spread function (PSF) analysis for the sequence was performed using MATLAB. For the baseline and two variations, signal in fluid (T2=1500ms), blood (T2=150ms), and fat (T2=300ms between 5ms-spaced readout refocusing pulses and T2=100ms between 75ms-spaced T2-Prep refocusing pulses) was calculated throughout the readout, assuming a worst-case, total fat-sat failure.

In vivo MRCP studies were performed in order to compare the baseline sequence to the two variations. The studies were performed on a GE Signa Excite 3T scanner with 40/150 (max amplitude, mT/m, max slew, mT/m/ms) gradients. Forty 2mm slices with 1mm in-plane resolution were acquired and reconstructed at 0.5mm×0.5mm×1mm. TR was synchronized with respiration. Parallel imaging (ASSET) with a 1.5× factor in the in-plane phase-encode direction was used. Effective TE was 500ms for the baseline case, 650ms for the first (acquisition delay) variation, and 500ms plus 150ms of T2-Prep for the second variation.

Results

Figure 1 shows the PSFs in each case for fluid (blue), blood (red), and fat (green). Based on the analysis, blood should be similarly suppressed by the delayed acquisition and T2-Prep variations, but fat should be better suppressed by the T2-Prep variation.

Figure 2 shows maximum intensity projections (MIPs) for an *in vivo* study. High frequency artifacts, particularly at blood vessels contaminated the hydrographic MRCP image and fat was incompletely suppressed in the baseline technique (a). By delaying acquisition by 150ms while "dummy" echoes were generated, much of the short T2 tissue decayed, reducing high spatial frequency energy, and suppressing image artifacts, however, unsuppressed fat remained in the image (b). With T2-Prep, high frequency artifacts were likewise suppressed while fat was better suppressed – overall much better background suppression was observed and the conspicuity of fluid-filed structures was improved. Note, in particular, that the pancreatic duct (arrows) within the tail of the pancreas was much better visualized in this case when using T2-Prep.

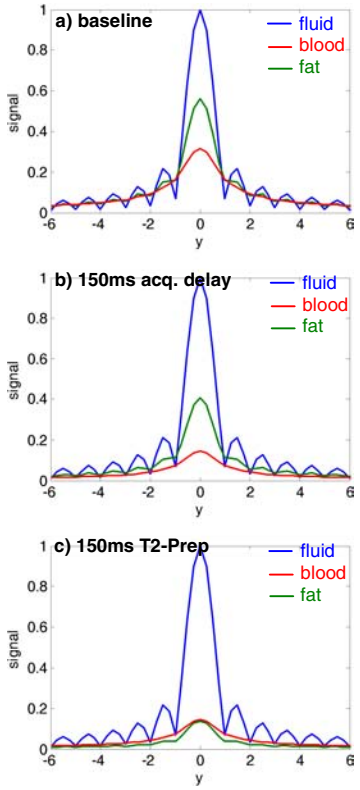

Figure 1 (above): PSF analysis suggests either delaying acquisition or T2-Prep will suppress blood vessel edge artifacts, but T2-Prep will better suppress fat.

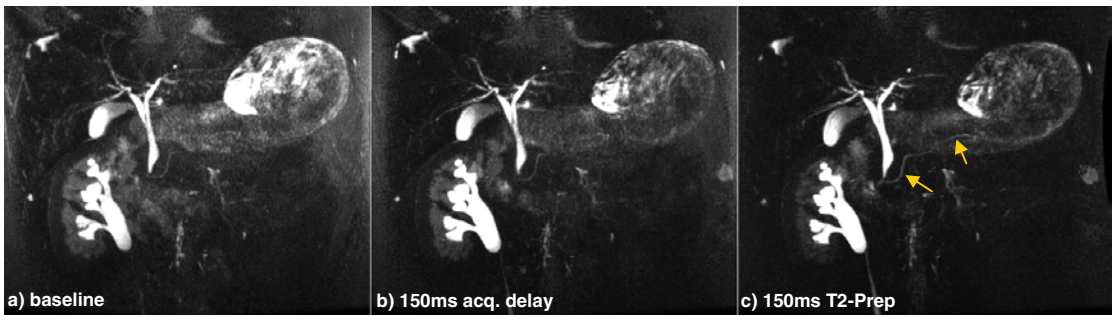

Figure 2 (left): *In vivo* MRCP studies confirm that T2-Prep suppresses both blood vessel edge artifacts and residual fat signal, improving conspicuity of small ducts. Visualization of the pancreatic duct (arrows) is particularly improved in this example.

Discussion

High contrast, high resolution MRCP has been demonstrated using a 3D-FRFSE sequence with T2-Prep. Barriers to complete background suppression, including incompletely suppressed fat and high spatial frequency artifacts from blood have been addressed. Like delayed acquisition (dummy echoes), T2-Prep allows signal in short and moderate T2 materials to decay before beginning acquisition, reducing the undesirable high spatial frequency contribution from blood. Unlike delayed acquisition, the widely spaced (75ms) refocusing pulses in the T2-Prep segment allow incompletely saturated fat to decay more rapidly, overcoming the "bright fat" effect that is commonly seen in FSE compared to conventional spin echo.

References: (1) Glockner, Proc ISMRM 2003, p1438; (2) Williamson, MRM 35:506 (1996); (3) Busse, Proc RSNA 2004, p588; (4) Brittain, MRM 33:689 (1995)