Investigating using Water Inversion Recovery (IR) to Resolve the Olefinic Resonance from Water in Breast *In Vivo* with Magnetic Resonance Spectroscopy at 3 T

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INTRODUCTION

- Levels of fat unsaturation are relevant to the study of disease, including liver disease, diabetes, breast cancer, and osteoporosis [1-7].
- Magnetic Resonance Spectroscopy (MRS) has been employed to quantify the olefinic resonance (≈ 5.4 ppm) to assess fat unsaturation *in vivo* [7-12].
- The water resonance (≈ 4.8 ppm) overlaps the olefinic resonance in short echo time (TE) spectra in tissues such as breast, spinal bone marrow, and liver, rendering its quantification challenging.
- Long-TE MRS sequences such as Point RESolved Spectroscopy (PRESS) have been optimized to measure olefinic to methylene (≈ 1.3 ppm) ratio in tissues with water content [9-11], exploiting the relatively shorter T_2 (transverse relaxation) time of water [11].
- At 3T, PRESS with a TE = 200 ms has been optimized for relative quantification of olefinic to methylene ratios in tibial and spinal bone marrow [11].
- A long TE results in significant signal loss of the olefinic protons due to T_2 relaxation.

AIM

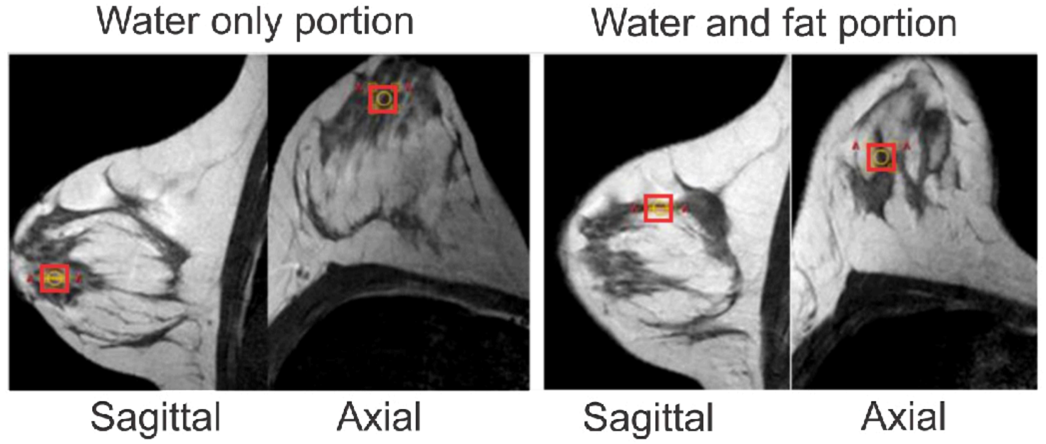
- To investigate using a PRESS MRS sequence with an inversion recovery (IR) pulse to suppress the water signal (≈4.8 ppm) that obstructs the fat olefinic resonance (≈ 5.4 ppm) in spectra acquired with short TE (echo time) from tissues containing both fat and water, such as breast.
- Olefinic signal yield from the short-TE IR method is compared to that obtained with a previously optimized PRESS long-TE (TE = 200 ms) that exploits the shorter T_2 time of water.

METHOD

- PRESS spectra (TE = 40 ms, repetition time (TR) = 3 s) were acquired from the right breast of a female volunteer using a 3T Philips whole-body MRI scanner with a Flex-L-two element surface coil and a specially designed breast board.
- Spectra were acquired from a water region of the breast with water inversion times of 250 ms, 450 ms, 550 ms, 650 ms, 750 ms, 850 ms, and 1000 ms.
  - The PRESS sequence was preceded by an inversion pulse set to the frequency of water, with 100 Hz bandwidth.
- The IR times were to used determine a delay that minimizes water signal (null time).
- Spectra were obtained from a voxel that contained both fat and water, using PRESS with TE = 40 ms and no IR pulse, PRESS with TE = 40 ms with an IR delay equal to the estimated null time, and PRESS with TE = 200 ms with no IR.
  - Figure 1 displays the localization of the 10x10x10 mm^3 voxel in the water-only region of the breast (to estimate a water null time) and in the water-fat region of the breast (to compare the IR technique with the long echo time method).
- Olefinic peak signal to noise ratios (SNR) were compared between the spectra acquired with IR and short TE (40 ms) and that acquired with no IR and long TE (200 ms).
  - The olefinic SNR was calculated by dividing the height of the olefinic signal by the standard deviation of the noise measured between 8-9 ppm.

RESULTS

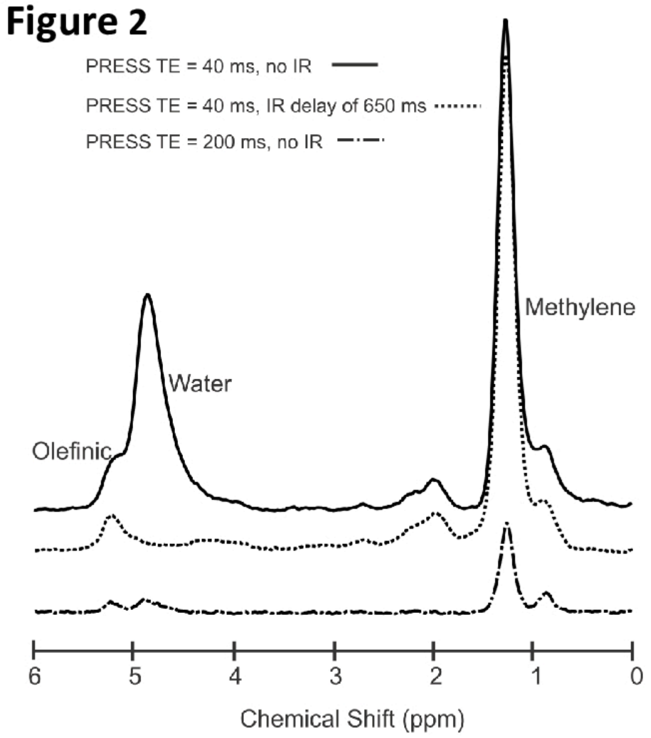
Figure 1



Voxel localization in a water region of the breast to estimate the water null time (left) and in a region of the breast containing both fat and water to apply the IR method and the long TE method for resolving the water and olefinic resonances (right).

- **Delay of 650 ms minimized water signal.**
- **Figure 2 displays spectra acquired from a voxel in the breast containing both water and fat using a short TE (40 ms) without IR, and using a TE of 40 ms and an IR delay time of 650 ms, which removes the water contamination.**
  - **The spectrum acquired using PRESS TE = 200 ms without IR is also shown; the water and olefinic signals are resolved; however the SNR is about three times lower.**
- **Future work includes assessing the impact of the inversion pulse on the olefinic resonance and verifying the efficacy of the technique on more volunteers.**

Figure 2



Spectra acquired from a voxel containing both fat and water in the breast.
Top spectrum: acquired using PRESS with a TE of 40 ms and no IR. The water signal overlaps the olefinic signal.
Middle spectrum: acquired with PRESS TE = 40 ms and an IR delay of 650 ms. Water signal is minimized.
Lower spectrum: acquired using PRESS with a TE of 200 ms and no IR. The water and olefinic peaks are separable; however, the olefinic SNR is three times lower.

CONCLUSIONS

- **Fat olefinic signal can be resolved from that of water at 3T in breast tissue using a short-TE PRESS sequence preceded by a water IR. Olefinic peak SNR is higher than that obtained with optimized long-TE PRESS.**

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