Rapid Fat Suppression in MRI of the Breast with Short Binomial Pulses

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Introduction: High spatial and temporal resolution is desirable in dynamic contrast enhanced MRI (DCE-MRI) of the breast to allow better assessment of lesion morphology and evaluation of enhancement kinetics, both of which are thought to aid in lesion characterization (1). The development of faster imaging techniques for dynamic contrast enhanced breast imaging is currently an area of active research.

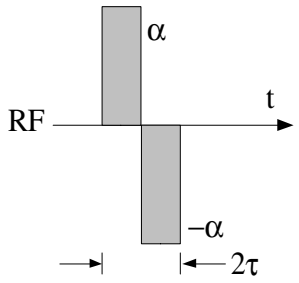

Figure 1: Rapid binomial pulse

Fat suppression is an important component of dynamic DCE-MRI of the breast (2). Fat suppression enhances lesion conspicuity and allows better evaluation of enhancement, particularly if pre and post contrast images are not accurately registered. The fat suppression or selective water excitation portion of a DCE-MRI pulse sequence typically contributes a major fraction of the total repetition time.

We present a method of fat suppression by water-only excitation conceptually similar to previously published "jump and return"(3) and phase modulated binomial pulses (4) but incorporating no interpulse delay. This method of water excitation allows good fat suppression in minimum time, allowing higher spatial and temporal resolution which may improve the accuracy of breast MRI for detection and characterization of breast cancer.

Methods: The rapid binomial pulse is illustrated in Figure 1. A hard α flip angle pulse is followed immediately by a second hard –α pulse. Both pulses are modulated at the resonant frequency of fat. For on-resonance fat spins, the total excitation is zero. For off-resonance spins (i.e. water), a non-zero flip angle is achieved. The magnitude of the achieved transverse magnetization versus off resonance frequency ω and pulse length 2τ is plotted in Figure 2 for several values of α.

Results: Figure 3A shows an image obtained with water-only excitation by the rapid binomial pulse utilized in a three-dimensional gradient-recalled echo sequence with flip angle α = 60° and total duration of excitation = 160 μsec (i.e. τ = 80 μsec). Figure 3B shows the same image location from the same sequence with a non-selective hard pulse in place of the rapid binomial pulse. Homogeneous fat suppression is demonstrated in Figure 3A.

Conclusion: The rapid binomial pulse with no interpulse delay achieves effective selective water excitation for dynamic breast imaging in as little as 160 μsec at 3.0T, compared to 600 μsec or more required for conventional frequency selective techniques. Shorter excitation allows lower TR, giving higher spatial and temporal resolution which may result in improved diagnostic accuracy for breast cancer.

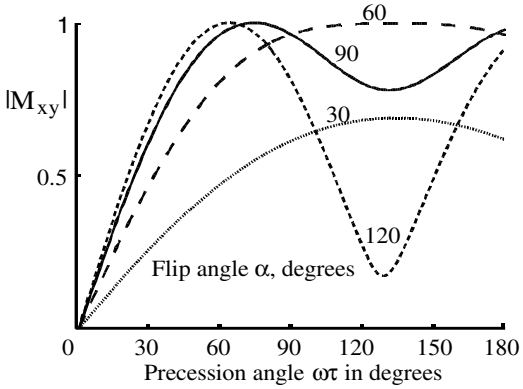

Figure 2: Magnitude of transverse magnetization versus off-resonance frequency ω. For water-only excitation at 3.0T with pulse length of 160 μsec,ωτ = 28°.

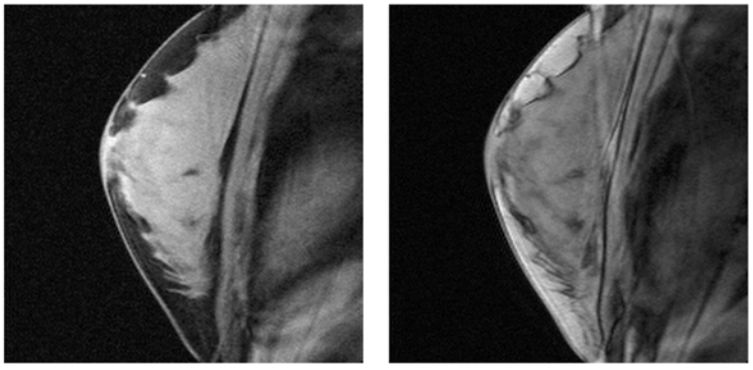

Figure 3: A) Water-only excitation with rapid binomial pulse, total excitation time = 160 μsec. B) Image obtained with same sequence with non-selective hard pulse.

References:

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