ANALYSIS OF NON-LINEAR EFFECTS ON SLICE SELECTION IN MR IMAGING

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INTRODUCTION

Slice selection in magnetic resonance tomography is achieved by selective excitation with a radiofrequency (RF) pulse which spectral width is narrower than the distribution of Larmor frequencies produced by the applied selection gradient. Ideally, one whishes to obtain a transverse magnetization which is zero everywhere, except for the selected region, for which m_x=0 and m_y= constant. This requires the use of some spin refocalization technique following the excitation. The non-linear response of the spin system plus the finite length of the RF pulses are the main difficulties in achieving the above ideal result. Here we make an analysis of the various possible alternatives to handle this problem and point out the most convenient pulse sequences for 2D image generation.

METHOD AND RESULTS

The m_x, m_y and m_z components of the magnetization were numerically calculated from the Bloch equations as a function of time and position for several gradient and RF pulse sequences and shapes(1). The spatial distribution of these components, at the time of maximum refocalization, was used to compare the results. Although the more complex sequences(2,3) give closer to the ideal results we limit the discussion to the simpler techniques consisting of one selective RF excitation pulse followed by some refocalization scheme. The conclusion of this study from the view point of the minimization of the non-linear effects are the following. For excitation best results follow from either a low flip angle or 90° time shifted pulse(2) of one of the following shapes: sinc x gaussian (with 3 lobes) or sinc x Blackman-Harris (with 1 lobe). For refocalization either a reverse gradient or non selective 180° pulse, which provide equivalent results, are the best choice, since selective 180° pulses produce strong non-linear response and should be avoided. Low angle excitation pulses produce practically no quadrature magnetization after refocusing and should be prefered when a quadrature excitation at a shifted frequency is employed as in some proposed techniques(4). Furthermore the apparent signal reduction for $\beta < 90°$ is compensated by reduced saturation effects when equal acquisition times are considered(5).

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