CHAPTER I

INTRODUCTION

1.1 THE USES OF THREE DIMENSIONAL MAGNETIC RESONANCE IMAGING (3D MRI) AND RADIO FREQUENCY (RF) PULSE

The three-dimensional MRI (3D MRI) provides more information than that of the conventional two-dimension slice due to data acquisition in one more dimension or by 3D Fourier domain. The intrinsically three-dimensional volumetric imaging sequence offers several advantages include: No information lost from gaps or “crosstalk” between difference slices [1], Increase signal to noise ratio (SNR) from a large coverage slab, Ease of achieve isotropic resolution [2], Possible to review and reconstruction in any planes, and Less redundancy scans when more information or detail in other planes is required.

Several ways of 3D excitation in MRI have been introduced. Typically, 3D slab excitation with phase encoding along the slice selective gradient during acquisition has been used. Multidimensional excitation especially stack of two dimensional (2D) selective excitations [3, 4] has also been applied. The applications of the 3D small volume excitation in MRI have been found in both MRI and Magnetic Resonance Spectroscopy (MRS). Currently, the small volume excitation has been done by employing a single pulse in two or three directions (x, y and z), with one direction at a time. The intersection volume from the three separate excitations represents the volume of interest (VOI). However, when a small volume of interest (VOI) is in a larger Field Of View (FOV), the 2D selective excitation with one none selective direction can cause the loss of information due to insufficient resolution in that small

VOI. The resolution problem in a small voxel can be reduced by the true three dimensional radio frequency (3D RF) excitation pulses that select only particular VOI in all three dimensions. The 3D RF excitation will limit the volume of interest (VOI) to be a smaller FOV in both excitation and acquisition. Therefore, with the same matrix size, the smaller FOV will provide higher resolution than that of the larger volume of excitation. This concept can be further extended to the case of isotropic resolution. Apart from the small volume excitation, the 3D RF excitation pulses are of interest in varieties of magnetic resonance applications, for instant to reduce susceptibility artifact of T_2* -weighted in functional MRI (fMRI) [5], and to reduce B_1 inhomogeniety at 3T [6].

1.2 PROBLEMS AND POTENTIAL SOLUTIONS OF THREE DIMENSIONAL RADIO FREQUENCY

The major limitation of the true 3D RF pulses is long pulse length due to spatially selective in all three directions, which requires more sampling points to meet the Nyquist criteria. Particularly, for a small voxel excitation, volume reduction is always the trade-off of increasing pulse width. The fast k-trajectories have been used in an attempt to efficiently cover the k-space in a short period of time, one of all has been known as spiral k-trajectory. Another approach of 3D excitation is the intersection volume from the three separate excitations that represents the volume of interest (VOI). To reduce the 3D RF pulse width is challenging. Several methods such as multi-shot [6, 7], variable density [8], and a fast k-z 3D TRF [9] pulse have been used to mitigate the problem.

1.3 SIGNIFICANCE OF THIS THESIS

This study aims to propose a novel multi-shot three-dimensional RF pulse with half-pulse design to reduce pulse width for small or reduce volume excitation. The half-pulse is potentially able to reduce the pulse duration and decrease the minimum TE. The small volume excitation promisingly increases information by increasing resolution in various clinical investigations such as pituitary micro-adenoma [7], Diffusion Weighted Imaging (DWI) of spinal cord [4], and Chemical Shift Imaging (CSI) multi-voxel in spectroscopy [10], yet the pulse design is challenging.

1.4 OBJECTIVES

1.) To develop and implement a new 3D TRF pulse that has a reasonable short pulse length and shorter TE for a small volume excitation.

2.) To validate the implemented pulse by simulation