High Resolution 3D Black Blood Carotid Artery Imaging using 3D TSE sequence with Non-Selective Refocusing RF and Inner Volume Imaging Technique.

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INTRODUCTION:

2D black blood carotid artery imaging obtained with turbo/fast spin echo (TSE/FSE) techniques with double inversion recovery (DIR) preparation is the current technique for identification of the component of carotid plaques(1-2). This approach is limited by inadequate spatial resolution that is often necessary to identify small areas of hemorrhage, fibrous cap disruption and other plaque components. 3D imaging offers the potential to improve spatial resolution in the slice selective direction. However, 3D black blood carotid imaging is limited by longer acquisition time and less effective blood suppression. The goal of this study is to reduce acquisition time and improve blood suppression for 3D TSE carotid imaging. To accomplish these objectives, we have utilized 3D TSE with non-selective 180^o refocusing pulses and have implemented an inner volume imaging technique. The non-selective 180^o pulses allow significantly more echoes to be acquired following each excitation resulting in more efficient 3D scan(3). The inner volume imaging technique reduces the field of view in the phase encoding direction and thereby requires fewer phase encoding line, further reducing scan time(4).

METHODS:

Carotid arteries of five human volunteers were scanned using variations in 3D TSE technique on a 3T Siemens Trio MRI scanner with our custom made four element bilateral phased array carotid coil. 3D TSE was performed with non-selective 180^o pulses, with and without inner volume excitation for FOV reduction and using different slice thicknesses. The use of non-selective 180^o pulses reduced the echo spacing to 4.3ms compared with 10 ms using a standard slice selective 180^o pulse. Double inversion recovery (DIR) was applied to suppress the blood signal. Scan parameters were: TR=700 ms, TE=17.2 ms, 256x256 imaging matrix, 13 cm FOV, 1 mm slice thickness, 2 averages and echo train length of 37. Total scan time for the 48 slice acquisition was approximately 7 min without inner volume technique. This scan time was similar to the 6:38min required for 2D multi-slice TSE black blood imaging with DIR for 24 slices and 2 mm slice thickness necessary to image the same length of artery(5). Figure 1 shows the pulse diagram of 3D inner volume TSE technique using non-selective 180^o pulses. To achieve the inner volume excitation, the first refocusing 180^o pulse was switched to be slice selective in the phasing encoding direction. For inner volume images, an asymmetric FOV (130x50 mm) with a 256 x 84 imaging matrix was used. Other parameters remained the same, and the scan time was reduced to 3 min 20 sec for acquisition of the same 48 slices. 3D TSE images with 0.5 mm slice thickness which has 0.5 mm isotropic voxel size were acquired using these same imaging parameters.

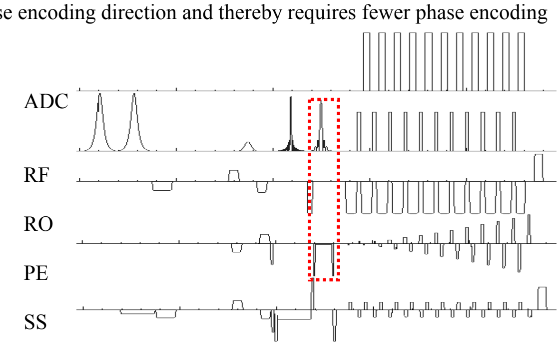

Figure 1 Pulse diagram of 3D TSE with non-selective 180^o pulses and inner volume imaging technique.

RESULTS:

Figure 2 demonstrates 2D T1, T2w and 3D T1w images of human carotid arteries from three identical slice locations. 3D TSE image of the same slice location but

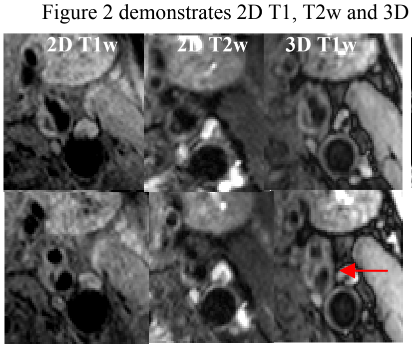

Figure 2 2D T1w, T2w TSE and 3D TSE images using non selective 180^o RF

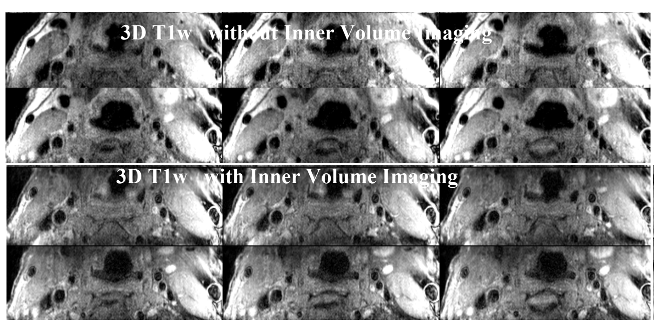

Figure 3 3D TSE images using non selective 180^o pulses with (and without inner imaging technique.

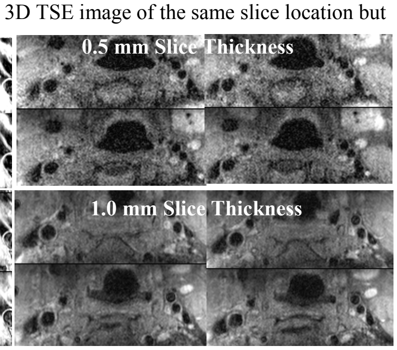

Figure 4 3D inner volume images of 0.5mm and 1.0mm slice thickness

with 1.0 mm slice thickness using non-selective 180^o pulses display better SNR and contrast. As the red arrow indicated, 3D images show the residual blood signal due to thick slab excitation. Figure 3 displays 3D images with (bottom) and without (top) inner volume technique. 3D images with the inner volume technique show comparable SNR as 3D TSE images without the inner volume technique. Further 3D inner volume images with 0.5 mm slice thickness (top) have slightly less SNR than images with 1.0 mm slice thickness (bottom) but show better blood suppression and spatial resolution than those with 1.0 mm thickness.

DISCUSSION:

3D TSE using non-selective 180^o pulses provides improved resolution for vessel wall images with minimal change in acquisition time. Implementation of the inner volume imaging technique into the 3D TSE sequence reduces scan time by over 50% while maintaining good SNR. 3D TSE inner volume images could achieve high resolution 3D wall images with 0.5 mm isotropic voxel dimension resolution. It has reduced SNR but this can be compensated for by averaging multiple scans, taking advantage of the reduced acquisition time. Blood suppression in 3D black blood imaging using DIR preparation is more difficult due to the increased outflow volume of blood in 3D slabs. Small slab size (20~24 mm) imaging has been employed to provide the necessary blood suppression in 3D imaging(4). Overall, this technique of 3D TSE inner volume imaging, by reducing acquisition time, improving spatial resolution and allowing for increased signal averaging without increasing overall scan time, provides significantly improved resolution of the components of carotid atherosclerotic plaques.

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