ROtated Slab Excitation (ROSE) for Reduced Foldover Artifacts in Coronal 3D Abdominal Imaging

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Introduction: Three-dimensional abdominal imaging is frequently performed in the coronal plane for many hepatic and renal imaging applications. However, applying the phase-encoding gradient in the left/right direction renders the acquisition vulnerable to aliasing artifacts from anatomy outside the prescribed field-of-view (FOV), especially on larger subjects or if the subject's arms are positioned at her sides. Because of field inhomogeneities at the edge of the bore, the aliased signal can create Moiré fringe artifacts due to phase interference. These artifacts can be severe when parallel imaging is applied as the different Moiré interference patterns on each coil can cause inaccurate reconstruction.

One possible solution to prevent arm wrap is to position the subject's arms overhead, but this is not a viable option for many patients. Another option is to prescribe a large FOV to encompass the entire anatomy, but this approach increases scan time for equivalent resolution. In this work, we investigate a ROtated Slab Excitation (ROSE) strategy for 3D coronal abdominal scans that significantly reduces the severity of foldover artifacts with minimal, if any, effect on scan time, spatial resolution, or other imaging parameters.

Methods: As illustrated in Fig. 1a, for conventional coronal acquisitions, RF slab excitation and slice-encoding (k_z) are both performed along the anterior/posterior (A/P) direction, frequency-encoding (k_x) is performed along the superior/inferior (S/I) direction to prevent aliasing along the longest anatomical dimension, and phase-encoding (k_y) is performed along the left/right (L/R) direction. The slab selection excites all spins within the slab; however, the encoded volume spans only the abdominal organs of interest. Any anatomy lying outside the encoded volume (e.g. arms, shoulders) is excited but not encoded, causing it to fold back into the image.

The ROSE method rotates the coronal slab excitation to the orthogonal sagittal plane to restrict the width of the excited volume to the encoded volume of interest (Fig. 1b). A similar approach was previously proposed for pulmonary vasculature imaging [1]. Any anatomy lying outside the slab is not excited and therefore cannot alias back into the image. The k_x, k_y, and k_z directions remain the same as before; the only modifications are the direction and width of slab selection, which is chosen to match the desired FOV in the phase-encode direction. While this acquisition is now vulnerable to slice-direction aliasing, the prescribed slices often cover most, if not all, of the full A/P patient width, minimizing such artifacts. In addition, Moiré fringes are less common in the A/P direction due to patient geometry.

The ROSE scheme was implemented in a 3D fast spoiled gradient echo pulse sequence and feasibility was tested in volunteer and patient abdominal imaging studies. After informed consent was obtained, imaging was performed on 1.5 or 3.0 T (Signa HDx, GE Healthcare, Waukesha, WI) scanners using an 8-channel torso coil. In some cases, 2D-accelerated parallel imaging [2] was used to increase spatial resolution and coverage within a breath-hold. All subjects were imaged with their arms at their sides.

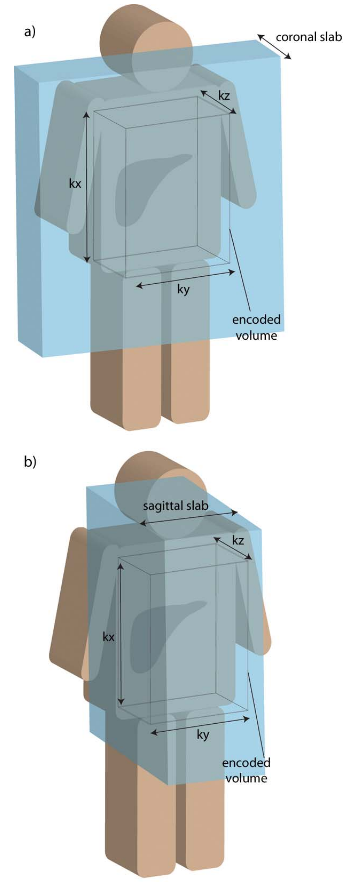

Figure 1. (a) Conventional and (b) ROSE acquisition scheme for 3D coronal abdominal imaging.

Results: Figure 2 demonstrates the severe aliasing artifacts that arise with conventional acquisition (left) when a narrow FOV is prescribed to "zoom in" on the kidneys of a volunteer; (right) the same scan repeated with the ROSE acquisition virtually eliminates all aliasing artifacts. Figure 3 shows post-contrast imaging results from a patient with polycystic liver and kidney disease whose hepatic vasculature was being evaluated prior to surgery. The standard coronal acquisition with 2D parallel imaging (left) shows foldover artifacts and Moiré interference patterns from anatomy outside the prescribed FOV that obscure the anatomy of interest. When the scan was repeated with ROSE (right), aliasing artifacts were dramatically reduced, allowing improved visualization of the vasculature (arrow). In all comparisons, the scan times for conventional and ROSE acquisitions were equivalent.

Discussion: This work demonstrates the utility of a rotated slab excitation scheme for 3D coronal abdominal imaging. This strategy exploits the fact that the slab-excitation direction for 3D imaging is independent of the slice-encoding direction and thus can be chosen to suit the anatomy of interest. The benefit of this approach is that high-resolution native slices remain in the preferred coronal plane while foldover artifacts are minimized. This technique could be extended to other applications where anatomy and scan plane render standard excitation schemes vulnerable to foldover artifacts.

References: [1]Wielopolski et al. Radiology 1992; 183:465-472. [2] Beatty PJ et al. Proc ISMRM 2006, 1749.

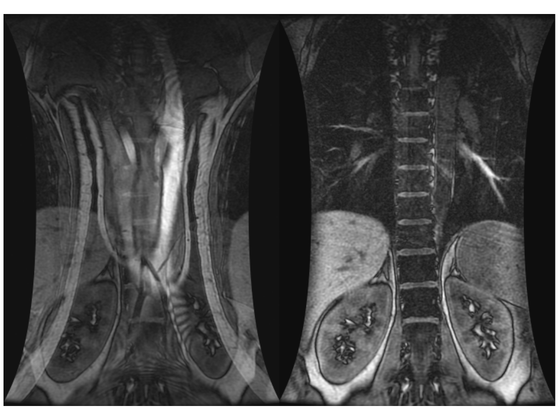

Figure 2. Conventional (left) and ROSE (right) acquisitions using a narrow FOV prescription for coronal renal imaging. Scan time was 27s for each acquisition. Note the dramatic reduction in aliasing artifacts.

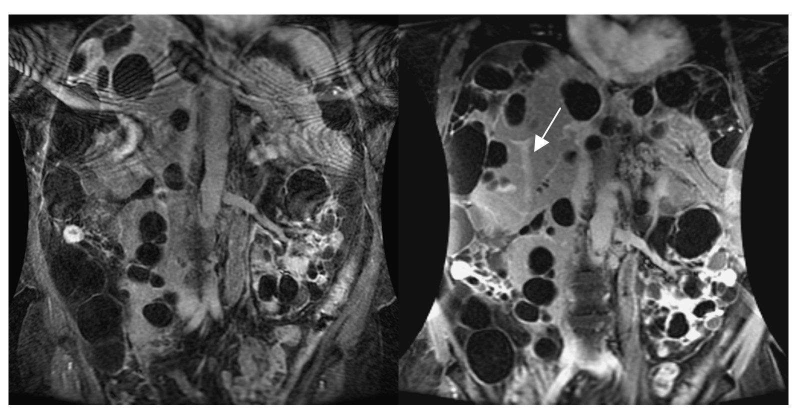

Figure 3. Conventional coronal 3D SPGR acquisition (left) showing foldover artifacts and Moiré fringe patterns from anatomy outside the FOV in a patient with polycystic disease. ROSE (right) significantly reduces these artifacts, offering improved visualization of the hepatic vasculature (arrow).