Limitations of 3D T2 SPACE for Evaluation of the Female Pelvis at 3.0T

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INTRODUCTION: MRI of the female pelvis requires high spatial and contrast resolution and multiplanar imaging to optimize visualization of anatomic structures which can vary widely in their orientation between patients and even within the same patient over time. High resolution 2D T2 TSE sequences are an essential component of the female pelvis protocol but can be very time consuming and require at least 3 planes of imaging specifically prescribed for each patient by the technologist to ensure appropriate orientation. If imaging is off plane or suboptimal, it may need to be repeated. A 3D imaging technique with high spatial resolution and multiplanar reconstruction capability would be very advantageous for imaging the complex female anatomy and could reduce overall scan time, by eliminating the need for multiple or repeat scans. A 3-dimensional (3D) T2 TSE sequence with RESTORE pulse and variable flip angle distribution (Sampling Perfection with Application Optimized Contrasts using different Flip Angle Evolutions-SPACE) has become available which offers the promise of high resolution volumetric T2 imaging with low T2 blurring and low SAR which is particularly useful at high field. However, there are several sources of concern with this type of sequence including potentially increased susceptibility to B1 homogeneity and uncharacteristic brightness of fat signal limiting distinction between fat and water. It is the purpose of this study to qualitatively and quantitatively compare a 3D SPACE sequence with 3 plane 2D TSE sequences for imaging of the female pelvis at 3T with sequence parameters modified to achieve similar time of acquisition and SNR.

METHODS: Waiver of consent was obtained for this IRB approved retrospective study. All female patients referred for imaging of the pelvis at 3.0T between May 2007-8 were included in this study. Multiphase (axial, sagittal and coronal with respect to uterus) 2D TSE using the following parameters TR/TE 4700-7700ms/98-104 ms, FA=175°, echo train length 15, slice thickness 4 mm, interslice gap of 1.2 mm, 24-37 slices, FOV 146-250 x 225-300 mm, matrix 166-269 x 448, signal averages 2. BW=200 Hz/pixel, iPAT=2 GRAPPA and Coronal SPACE (TR/TE= 1600/107-119, FA= variable°, ETL=159, ST=1 mm, 160-208 partitions, FOV 400 x 400, matrix 378 x 384, signal average 1, BW=465 Hz/pixel, iPAT=3. Three experienced readers reviewed the data sets in random order with at least 4 weeks between readings of the same patient. Readers assessed overall image quality (IQ), diagnostic quality, artifacts, identified and measured normal anatomic structures, evaluated pathology and recorded the time of interpretation. Comparison was made between scores of IQ and intra-observer variability between sequences. Subsequently, individual readers performed a side by side comparison of the sequences in each patients and preference was graded (1=Strongly prefer 2D TSE, 2=slightly prefer 2D TSE, 3=no preference, 4=slightly prefer SPACE; 5=strongly prefer SPACE) on the basis of 9 parameters (Fig. 1) and asked if interactive 3D MPR using 3D SPACE was (i) not useful, (ii) useful but not necessary or (iii) essential for diagnosis in each patient. Quantitative assessment was performed by an author not involved in the interpretation. The 3D SPACE sequence was reconstructed to similar slice thickness as 2D TSE in all three planes and SNR was compared. Since parallel imaging was employed, with consequent spatially-varying noise, relative SNR was calculated as SI/SED for endometrium, inner (IZ) and outer myometrium, subcutaneous fat and bladder fluid.

RESULTS: 20 patients were included in this study. Pathology included fibroids (n=14), adenomyosis (n=3), nullerian duct anomaly (n=4), ovarian mass benign or malignant (n=9), endometrial mass (n=6) and cervical mass (n=4). In 3 patients, one data set of 2D TSE was repeated and in 1 patient, the SPACE was repeated, because of sub-optimal image quality determined at the time of scanning. There was no significant intra-observer inter-sequence variability in distinction of zonal anatomy of the uterus and cervix, recognition of uterine fibroids and adenomyosis or nullerian duct anomalies, measurement of endometrial thickness or in interpretation time. There was a significant difference in IZ thickness measures for 1 reader (p<0.05). Yet, there was also no significant difference in individual ratings of overall imaging quality or diagnostic quality. For 1/3 readers, significantly more artifacts were noted on SPACE (p<0.05) including B1 inhomogeneity, ghosting and motion artifacts. For all three readers, there were significant differences in calling of ascites (p<0.01) with 2D sequences being more sensitive (Fig. 2). Mean acquisition time for SPACE was significantly shorter at 6 min 29 sec versus 8 min 9 sec (p< 0.005) for 3 planes of 2D sequences. Based on the side by side comparison, there was an overall slight preference for 2D TSE (score of 2.6) vs. 3D SPACE especially for distinguishing fat from fluid (Fig. 1). In 5 patients 2/3 readers considered SPACE useful but not necessary for visualization of pelvic anatomy and pathology and in only 1 case did 2/3 readers consider SPACE essential for diagnosis. SNR for most tissues was comparable for the two sequences (and slightly, but significantly, better for SPACE, although this must be considered in terms of slightly different spatial resolution and acquisition times). Notably fat had markedly (2x) and significantly higher SNR on 3D SPACE (58.3+/−17.5) vs. 2D (27.1+/−6.8) sequences (Fig. 3).

DISCUSSION: Our findings show no significant difference in overall image quality or diagnostic quality between 3D SPACE and 3 plane 2D TSE. Overall, readers slightly preferred 2D TSE most often because of the lack of distinction between fat and fluid on SPACE and artifacts including B1 inhomogeneity (most apparently affecting bladder signal) and motion (problematic on both sequences). Despite the use of dielectric pads, B1 inhomogeneity can degrade image quality at 3T but may be improved in future with advances in higher order parallel imaging and parallel transmission. More significantly, the tissue contrast particularly between fat and fluid is problematic likely due to j-coupling effects; future optimization is warranted possibly with application of frequency selective fat suppression to optimize contrast and variation of the flip angle evolution to cater to the T2 relaxation times of tissues in the female pelvis. The main advantage of 3D SPACE is volumetric, isotropic, high resolution imaging permitting arbitrary plane reformatting and therefore, is suitable to completely replace T2 TSE but has significant potential and should be further optimized.

Figure 1: Average Reader Preference 2D versus 3D

Figure 2: Axial a) 2D TSE b) axial reformatted SPACE at a similar level demonstrating B1 inhomogeneity effects over the anterior pelvis (*) more apparent on SPACE and poor fat/fluid distinction on SPACE (arrows) compared to 2D TSE

Figure 3: Mean SNR of Pelvic Tissue 2D vs. 3D