Evaluation of Uterine Anomalies with 3D-FSE-XETA (eXtended Echo Train Acquisition)

J. G. Williams[1], E. Sadowski[1], J. L. Hinshaw[1], and R. Busse[2]

[1]Department of Radiology, University of Wisconsin, Madison, WI, United States, [2]Global Applied Science Lab, GE Healthcare, Madison, WI, United States

OBJECTIVE: Congenital uterine anomalies occur in 0.4% of all women, but are detected in up to 8-10% of women with recurrent pregnancy loss [1]. Ultrasound, hysterosalpingography, and hysteroscopy have been utilized for detection in the past, but MRI represents a non-invasive, and more accurate alternative [2]. Given the oblique and often irregular curved orientation of the uterus, conventional 2D acquisitions do not always capture the images needed to evaluate the uterine contour. This scenario can become particularly problematic when a technologist who is unfamiliar with the appropriate planes is not directly assisted by the radiologist at the time of image acquisition. With the novel 3D-FSE-XETA (eXtended Echo Train Acquisition) technique [3], a T2-weighted volumetric dataset of the entire uterus and surrounding anatomy is acquired with near isotropic (1.0 x 1.2 x 1.4mm) resolution in 5 minutes. The radiologist can then interactively reformat images to view the anatomy in any orientation. The purpose of this study is to evaluate the utility of the 3D-FSE-XETA technique in interrogation of uterine anomalies.

SUBJECTS AND METHODS: Patients referred for a non-contrast pelvic MRI to evaluate the possibility of uterine anomaly presence were recruited for this study. The MRI protocol included three T2-weighted 2D FSE acquisitions in axial, sagittal and oblique (sagittal to uterus) planes. (TR=2500ms, TE=85ms, FOV=24-36cm, matrix=320x256, 12-24 slices 5mm thick with 1.5mm skips, scan time ~13 min for three orientations). Additionally, the 3D-FSE-XETA sequence was added for a volumetric T2-weighted acquisition (TR=2500ms, TE=105ms, FOV=24cm, matrix=256x224x128, slab coverage = 18cm, acquired voxel size 1.0 x 1.2 x 1.4mm, scan time 5 min). 3D-FSE-XETA utilizes self-calibrated parallel imaging and modulated flip angle (35-120°) refocusing RF pulses that enables very long echo trains (ETL=126) to generate T2-weighted soft tissue images with little blurring and low RF power. Zero filling (sinc interpolation) in three dimensions was used to reconstruct 0.5 x 0.6 x 0.7mm voxels, allowing clean reformats of the 3D data in multiple planes to visualize the uterus.

RESULTS: Figure 1 demonstrates a bicornuate uterus visualized simultaneously in three orthogonal planes from the same 3D dataset. Figure 2 shows a complete septate uterus visualized with a curved reformat, allowing the entire structure to be displayed from the cervix to the fundus. The reformatted image nicely demonstrates the septum in its entirety while also displaying the uterine contour. Clear demonstration of the uterine horns and contour facilitates distinction of didelphys, bicornuate, and septate anomalies. This distinction alters the clinical management of the patient. The uterine contour is often more difficult to evaluated on the 2D images, making uterine anomaly differentiation more challenging.

DISCUSSION: The 3D-FSE-XETA technique allows a single 5 minute acquisition to be used in characterization of uterine anomalies. Because the voxels are nearly isotropic, the orientation of the reformat has very little impact on resolution. In contradistinction, reformats of the 2D datasets exhibited prominent blurring due to the relatively thick slices and spacing between the slices. While the 2D images had higher in-plane resolution, the scan time for the three 2D acquisitions was more than threefold that of the single 3D acquisition when time to prescribe and transition between the separate series was taken into account. Additionally, curvature and inconsistent orientation of the uterus can lead to sub-optimal positioning of 2D slices, whereas retrospective reformatting of the 3D data provides a clear advantage for investigating the anatomy. In practice, the 2D axials may be retained in the clinical protocol. However, the 2D axials could be acquired with an alternate contrast, such as with fat suppression, to increase the amount of information gathered while decreasing the overall scan time.

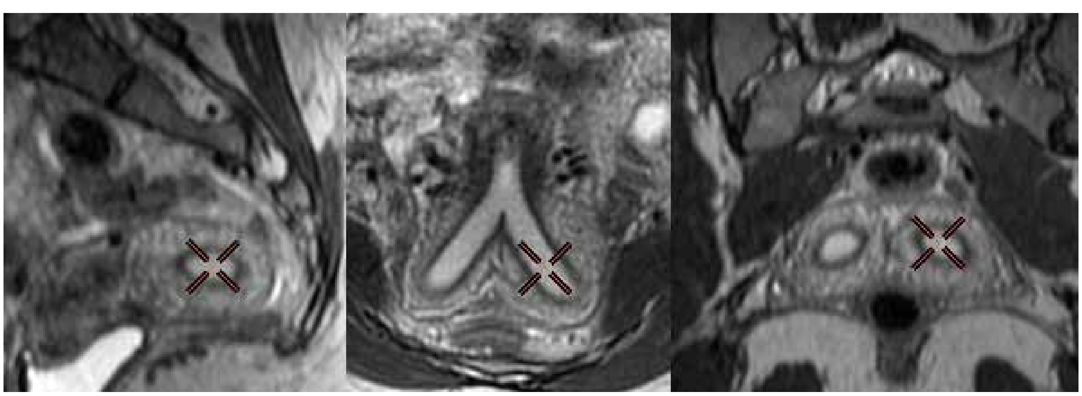

Figure 1: Near isotropic voxel dimensions allows reformats of the 3D-FSE dataset in any direction. Sagittal, oblique axial, and oblique sagittal reformats demonstrate a bicornuate uterus.

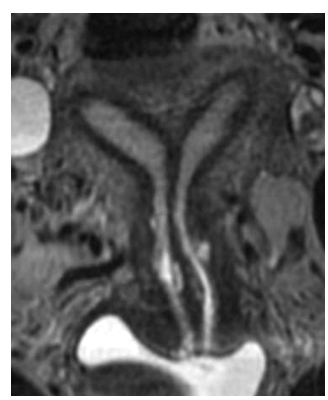

Figure 2: Curved reformat of a complete septate uterus.

References:

[1] Troiano RN, McCarthy SM, "Müllerian Duct Anomalies: Imaging and Clinical Issues" *Radiology* 233:19-34 (2004)
[2] Woodward PJ, Wagner BJ, Farley TE, "MR imaging in the evaluation of female infertility" *RadioGraphics* 13:293-310 (1993)
[3] Busse RF, Hariharan H, Vu A, Brittain JH, "Fast Spin Echo Sequences with Very Long Echo Trains: Design of Variable Flip Angle Refocusing Schedules and Generation of T2 Contrast" *Magn Reson Med* 55:1030-1037 (2006)