Faster and improved MRI of rectal tumors with a two sequence protocol based on high-resolution free-breathing post-contrast 3D SPGR imaging with comparison to standard care.

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Target Audience: Clinicians who image and stage rectal tumors. Researchers interested in free-breathing post-contrast imaging in the pelvis.

Purpose: Standard protocols for MRI staging of rectal tumors include 3-4 planes of T2-weighted imaging, and often include DWI and pre/post-contrast T1-weighted imaging [1]. The T2-weighted imaging alone requires more than 20 minutes of scan time, with an average study taking 30-40 minutes. We investigated whether staging of rectal tumors could be accomplished and possibly improved utilizing a streamlined 10-minute protocol consisting of a single axial T2 sequence with fat suppression (FS), plus a single high-resolution free-breathing post-contrast fat-suppressed 3D SPGR sequence.

Methods: With IRB approval we retrospectively identified 20 consecutive patients referred for 3T MRI staging of rectal cancer over a 7-month period whose exams included the necessary sequences (Table 1). All studies were performed with a 32-channel phased array torso coil, and field of view was adjusted to patient anatomy, except for the small field of view (sFOV) sequences where it was set to 22-cm. Rectal gel and intramuscular glucagon as a spasmolytic were administered immediately prior to each scan. The high-resolution, axial, free-breathing 3D SPGR sequence utilized an intermittent spectrally selective inversion recovery fat suppression pulse, was acquired at 1.2-mm (18 cases) or 1.6-mm (2 cases) slice spacing interpolated to 0.6 or 0.8 mm, respectively, and had a scan time of 4-5 min.

Conventional Bundle		Fast Bundle	
Axial fat suppressed T2	416 x 224 TE 100	Axial fat suppressed T2	416 x 224 TE 100
Sagittal small FOV T2	512 x 256 4 mm slices 22 cm FOV TE 120	High-res post-contrast 3D SPGR	416 x 416 1.2 mm slices FOV 30-38 cm
Ax Oblique small FOV T2		Reformat to Obliques: Axial, Sagittal, Coronal	
Cor Oblique small FOV T2			
Ax multiphase pre/post-con 3D Dual Echo SPGR	320 x 224 3 mm slices Breath-held 6 phases		
Scan time ~30 minutes		Scan time ~10 minutes	

Table 1: Imaging bundles used for evaluation.

Each exam was divided into two bundles (Table 1). The "conventional" bundle consisted of all T2 sequences, plus pre/post-contrast dual echo 3D SPGR (LAVA-Flex) sequences. The "fast" bundle consisted only of the axial T2 FS and the high-resolution 3D SPGR sequences with axial/coronal/sagittal oblique reformats provided. Two readers evaluated either the conventional bundle or fast bundle for each patient in an alternating manner. Readers recorded imaging findings relevant to staging of rectal cancer, such as penetration of the muscularis propria or invasion into adjacent pelvic structures, and assigned a confidence measure from 1 (poor) to 4 (high) for the presence or absence of each finding. These reads were utilized to stage the tumor per AJCC guidelines for rectal cancer (19 cases) or rectal gastrointestinal stromal tumor (GIST, 1 case). For the gold standard, staging was derived from pathology reports if the patient went to surgery prior to other treatments, or from the clinical stage (reflecting a consensus of imaging results including PET/CT as available and clinical findings) for those patients who underwent neoadjuvant therapy. The confidence score for T (primary tumor) and N (nodal) components of staging were calculated based off of the specific imaging feature that lead to the assessment. For incorrect assessments, the confidence was reassigned to a 1 for the purposes of comparison. The null hypothesis of no significant difference was assessed with a two-tailed Mann-Whitney U test with a p value ≤ 0.05 considered significant.

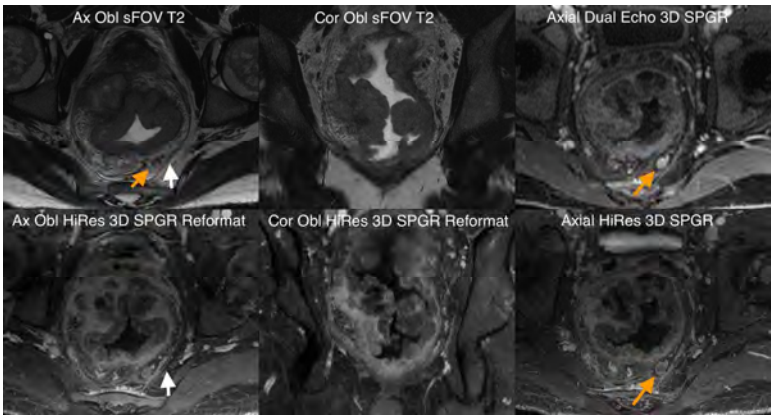

Fig 1: Representative images from a patient with a T4N2 rectal adenocarcinoma. Note that the high resolution 3D SPGR sequence is acquired at a relatively late phase of contrast enhancement where tumor is delineated by its washout from surrounding stroma. A metastatic lymph node demonstrates washout on the high resolution sequence (orange arrow). The mesorectal fascia can be identified on both the T2 and high-resolution sequences (white arrow).

Results/Discussion: Patient ages ranged from 26-90 years with 14 males/6 females. Tumor histology consisted of 18 cases of adenocarcinoma, 1 rectal leiomyosarcoma, and 1 rectal GIST. Representative images are shown in Fig 1. The distribution of staging performed from the conventional and fast bundles are shown in Fig 2A, with the pathology/consensus clinical staging included for comparison. Staging from the conventional and the fast bundle exactly matched the consensus clinical staging in 10 and 15 of the 20 cases, respectively. This difference was not statistically significant because of the relatively small sample size.

The conventional and fast bundles were incorrect on T-staging in 8 and 3 cases, respectively; this difference was not statistically significant. Differences in confidence score assessment of T-staging were statistically significant (Fig 2B). For nodal staging (N0 vs N1-2), the conventional and fast bundles were incorrect in 7 and 2 cases, respectively; this difference was not statistically significant. Differences in confidence score assessment for N-staging were statistically significant (Fig 2B).

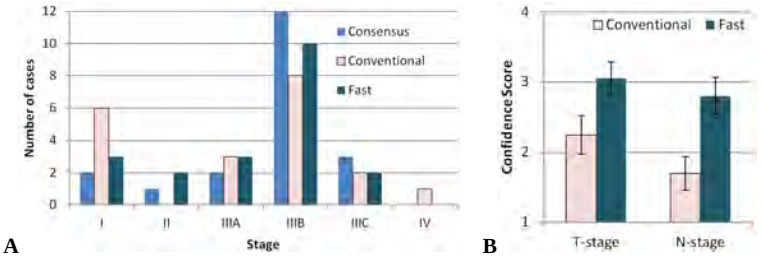

Fig 2A: Distribution of rectal cancer stages based on pathology/clinical consensus, and reads from the conventional and fast bundles. **2B:** The fast bundle led to significantly significant increases in reader confidence scores for T and N-staging. Error bars are standard error of the mean.

Conclusion: A fast imaging protocol utilizing a high-resolution free-breathing post-contrast sequence led to statistically increased reader confidence in T and N staging for rectal cancer, as well as a non-significant trend toward improved accuracy of staging. This fast protocol greatly reduces total scan time from 30-40 min to 10 min, and may improve diagnostic accuracy.

References: [1] Kaur H, *et al.*, "MR Imaging for Preoperative Evaluation of Primary Rectal Cancer: Practical Considerations", *RadioGraphics* 2012; 32:389-409.