**Supplemental Material**

*Simulation and initial plan*

Briefly, the clinically-deployed, Meridian (ViewRay, Sunnyvale, CA) MR-IGRT unit comprises a low-field split-solenoid 0.35 Tesla MRI unit straddling a ringed gantry with three, equally-distributed, MLC-equipped 60Co heads. All patients underwent CT and MRI simulation per standard clinical protocol, with custom immobilization. Exhale-breath-old simulation CT scans were used as primary image sets for density information and treatment planning, with registration of simulation MR-images to guide physician segmentation of target volumes/OARs.

*Daily online plan adaptation*

At time of clinical setup for each treatment fraction, patients underwent high-resolution volumetric magnetic resonance (MR)-imaging at exhale-breath-hold in the treatment position and were then aligned to the gross tumor volume (GTV) to maximize plan/tumor overlap. The Meridian (ViewRay, Sunnyvale, CA) MR-IGRT system daily imaging comprises a balanced steady-state free precession sequence combining T1 and T2 signals. Daily volumetric imaging in this study had transverse plane resolution of 0.17x0.17cm2 with 0.3cm slice width, with an acquisition time of 17 seconds. Deformable or rigid registration was used to transfer contours and electron density maps to daily setup MRIs from the treatment-planning CT dataset. Contours were manually edited, as needed, by treating physicians to account for daily changes in organ-at-risk (OAR) anatomy. GTVs were not edited in this study, given the low likelihood of tumor volume change over five treatment days. While the lower field strength of 0.35T is lower than typical diagnostic imaging systems, its utility and performance for daily patient setup and structure delineation for online adaptive radiotherapy have been demonstrated previously and have been implemented for routine patient care since January of 2014. Once any necessary contour adjustments were made, transferred electron density maps were evaluated and corrected as needed, then utilized to recalculate projected dose of the original, non-adaptive plan applied to daily anatomy. Treating physicians then evaluated initial plan performance based on predetermined OAR constraints (Table 2) and PTV coverage.

If application of the initial plan to anatomy-of-the-day led to OAR constraint violation or inadequate PTV coverage, adaptive plans were created using plan reoptimization with maintenance of original beam angles, but with new segments and times, while patients remained on the treatment table. Following physician approval of adapted plans, online plan QA was performed using independent, Monte-Carlo-based dose calculation and plan parameter verification by the covering physicist. Plan adaptation was also permitted at the discretion of the treating physician if they observed favorable daily anatomy that allowed for PTV dose escalation up to a total dose cap of 60Gy, while adhering to hard OAR constraints. In order to take maximum advantage of treatment days where favorable anatomy was observed, treating physicians were permitted to condense treatment to 60Gy/4fx (15Gy/fx), provided that OAR constraints could still be met.

Identical OAR constraints were used for all initial and online adaptive plans (Table 2). Gastrointestinal OAR dose-accumulation was not feasible at the time of this study. Therefore, hard OAR constraints were applied in a fraction-by-fraction manner such that the summative dose to any OAR point-volume could not exceed constraints. After adaptive plan generation, adaptive and initial plan performance were compared on the basis of constraint achievement and dose volume histograms (DVHs), with subsequent delivery of the superior plan.

*Treatment delivery and cine gating*

All fractions were delivered with custom immobilization at free breathing, with real-time 2D sagittal cine-MR gating in a single, physician-selected plane at a rate of four frames per second. For all patients, cine-MR gating was based on the gross tumor volume (GTV) itself. Gating boundaries were defined using a 3mm volumetric GTV expansion upon the exhale breath hold set-up images. Exhale breath hold was chosen as the gating baseline due to longer dwell time in that portion of the respiratory cycle and for reproducibility without coaching. When the GTV was within the gating boundary during treatment delivery, the beam automatically turned on; if the GTV moved outside the gating boundary, the beam turned off. Continuous imaging for cine gating not only tracks the identified target to preclude the need for fiducial markers or target surrogates, but also permits monitoring of positions of organs-at-risk during treatment for physician assurance of anatomic localization. The lower magnetic field strength utilized in the MR-IGRT system employed in this study enables continuous imaging without risk of patient heating.

*GTV dose accumulation*

GTV dose accumulation was achieved by rigid alignment of the daily dose distribution from each fraction to the first fraction, based on the centroid of the GTV volume, and addition of the dose from all fractions. The daily dose distribution is the delivered dose from a given fraction, accounting for the variations in patient position relative to isocenter, as well as any variation in electron density. While this approach was feasible for the GTV contour, which was not edited between fractions, it could not be applied to surrounding OARs without use of deformable registration to track dose between fractions. Work is in progress to develop a deformable registration technique that accounts for the large observed magnitude of variation in gastrointestinal structures on an inter-fraction basis, as none are yet availablew.

*Online plan quality assurance (QA) process*

After decision is made to use an adaptive plan for treatment, online quality assurance (QA) is performed.  The plan data (images, structures, dose volume, and a map of relative electron density) are exported to a shared network drive to provide input for an independent dose calculation. Information about the relative electron density, the exterior (skin) contour, the planned MLC positions, and the planned times are used to calculate dose with an independent Monte Carlo algorithm based on the same model as in the ViewRay TPS. Results of this QA step are displayed as both a dose difference and a gamma comparison.  The 3%/3mm gamma result has a tolerance of 95%, or within 5% of the original plan for the same patient.

The second step in the QA process is to run an in-house script that verifies the overall plan quality.  This includes a check for any gaps or islands in the contours, density overrides, contour volumes, a visual representation of the density map, and the total overall treatment time.  Lastly, a document is printed showing the new expected treatment times for each angle (accounting for the Co-60 source strength of the day), to ensure the plan that is about to be treated is indeed the correct one.  This is also done via in-house QA software.

Supplemental Figure 1. Mean global quality-of-life scores for patients at 0, 6, and 26 weeks post-radiotherapy completion.

