Abstract ID: 15471 Title: A Method for 2D-to-4D Sorting of Dynamic MRI to Derive An Anatomic Representation of the Average Breathing Cycle

Purpose:
Beneficial “4D” treatment planning and delivery methods, most of which are under development, rely on robust characterizations of motion. Implementation of these 4D methods may be hindered by deficiencies in current pre-treatment imaging. 4D-CT is the current standard for deriving patient-specific margins. However, 4D-CT is sub-optimal because it represents a single-cycle “snapshot” motion per slice location which results in slice-to-slice inconsistencies for variable breathing. Moreover, 4D-CT involves ionizing radiation. MRI is not thusly encumbered. We have developed a 2D-to-4D sorting technique for dynamic MRI to derive an average-breathing-cycle anatomic representation for radiotherapy planning.

Methods:
Healthy lung and abdominal volunteers were imaged continuously for 10-30 minutes with balanced steady-state free precession (bSSFP) and/or half-Fourier single-shot turbo spin echo (HASTE) on a 1.5T MRI system (MAGNETOM Espree, Siemens). 3D volumes were scanned in sagittal or coronal planes by changing the slice location per frame. Voxels were 2×2×5 mm3 and sequence parameters were adjusted to achieve repetition times of 200-300 ms. Synchronous with image acquisition, an external respiratory trace was collected at 50 Hz.

Results:
A two-step sorting technique based on the respiratory trace was developed. In the first step, all frames per slice location and phase bin were averaged, producing an “average 4D-MRI.” From this we derived corresponding “standard deviation 4D-MRI.” Frame averaging resulted in blurring. In the second step, raw frames were compared to the set of images per slice location from the average 4D-MRI; a normalized cross-correlation scoring criterion over a user-selected rectangular ROI indicated the best-matching respiratory phase anatomically. The subset of best-matching raw frames per slice location and phase were averaged to produce a final representation with improved contrast.

Conclusions:
Dynamic MRI shows great promise as a potential standard for motion management. Future efforts will involve modifications to the bSSFP sequence for significant improvements in speed.

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