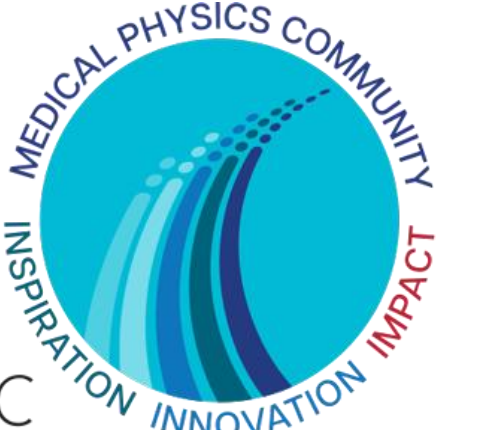


Evaluation of a 3D stack-of-stars MR sequence for respiratory hysteresis characterization in a motion phantom

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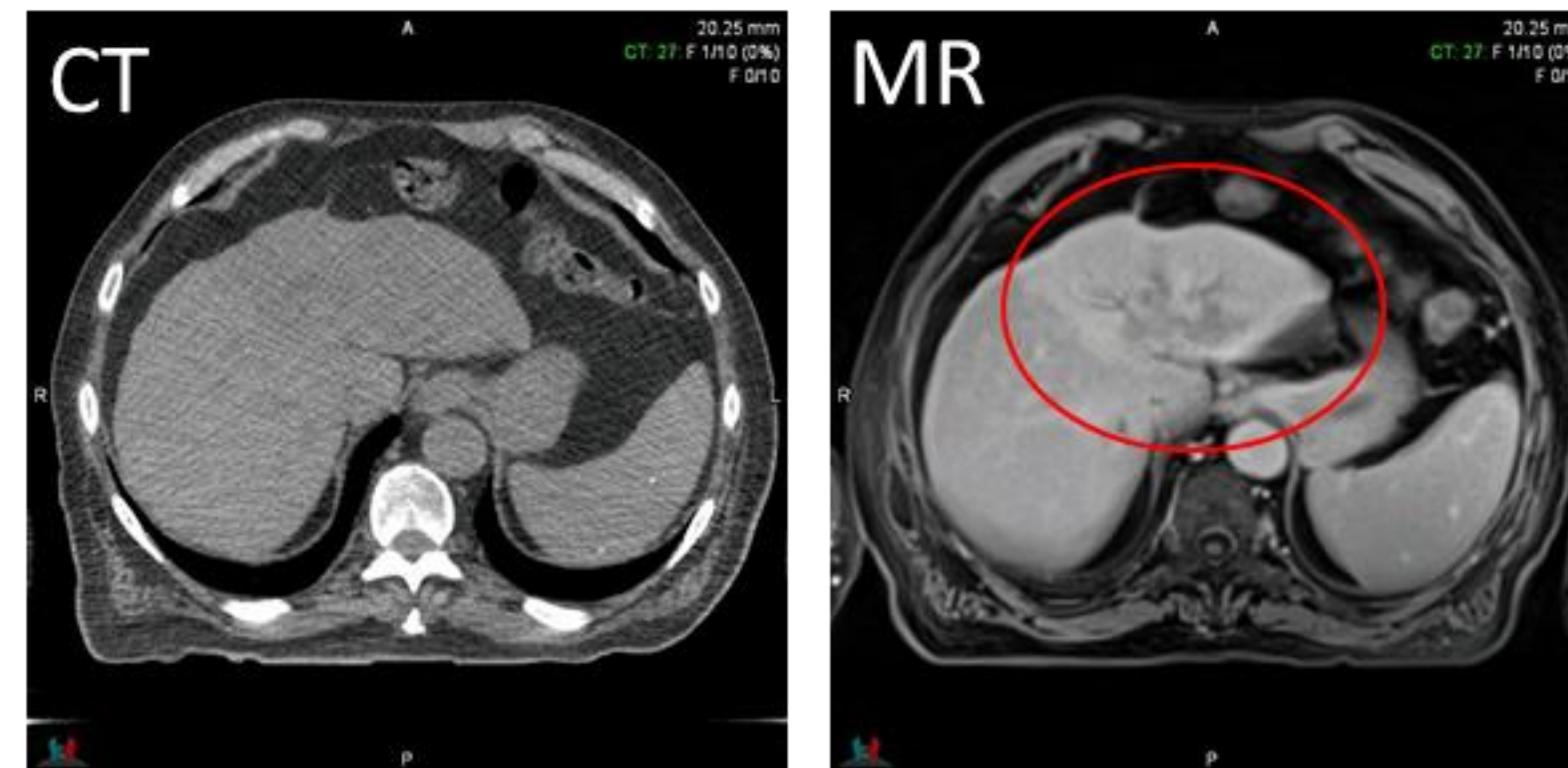
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Introduction

- 4D-MR offers an alternative to 4D-CT with its superior soft tissue contrast without dose to the patient¹.
- Prior work on 2D sinusoidal and irregular motion in a phantom has shown 4D-MR to have similar motion measurements as 4D-CT².
- 4D-MR uses amplitude averaging which does not account for hysteresis.
- **This study evaluates the measurement accuracy of transverse and coronal 3D stack-of-stars MR sequences relative to 4D-CT and physical ground truth, using a phantom undergoing hysteretic and non-hysteretic 3D sinusoidal motion.**

Figure 1: Differences between CT [left] and MR [right] on soft tissue contrast. The liver lesion in CT is difficult to discern, but in MR, the borders are clearly defined. This improves motion characterization through more accurate delineation of the tumor.



Methods

Phantom

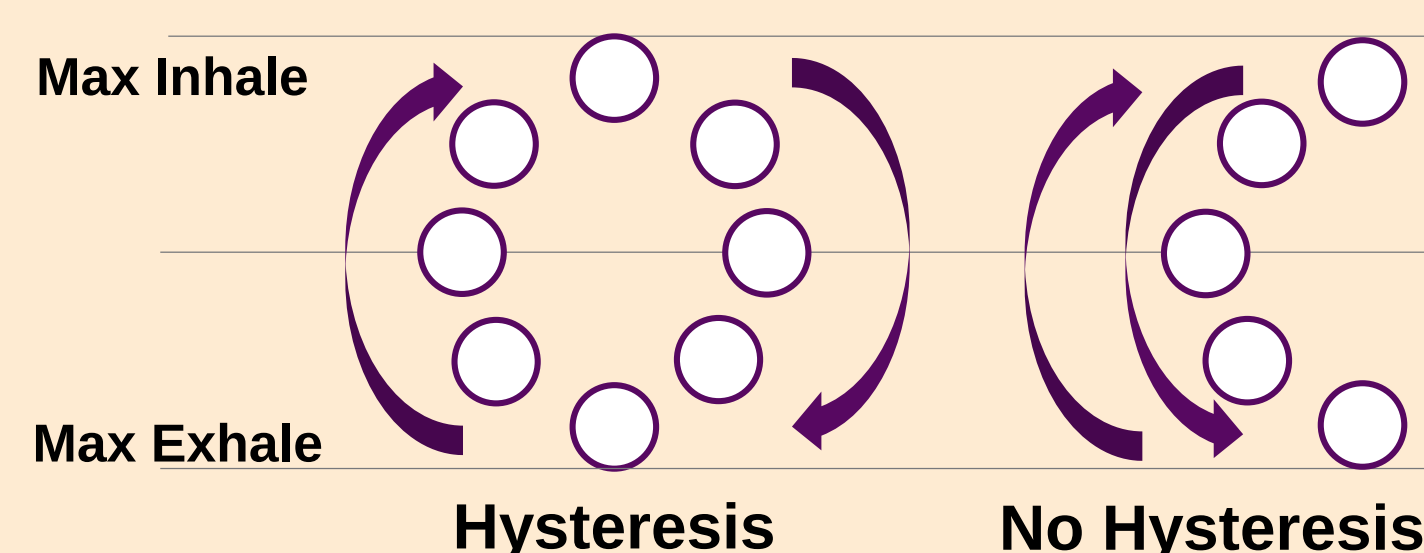


1.5T MR-sim (Sola)	
Flip Angle (°)	10
TR (ms)	3.98
TE (ms)	2.39
FOV (mm)	380 x 380
Matrix	256 x 256
Resolution (mm)	1.5 x 1.5 x 3
BW (Hz/Px)	601
Acquisition Time (min)	7:55

Figure 2: Scan parameters for the StarVIBE sequence.

- Quasar MRI 4D Motion Phantom with a Gd-filled spherical insert
- Siemens Magnetom Sola 1.5T MR scanner
- Sequence: Clinical 3D radial “stack-of-stars” (StarVIBE)
- CT as gold standard comparison.

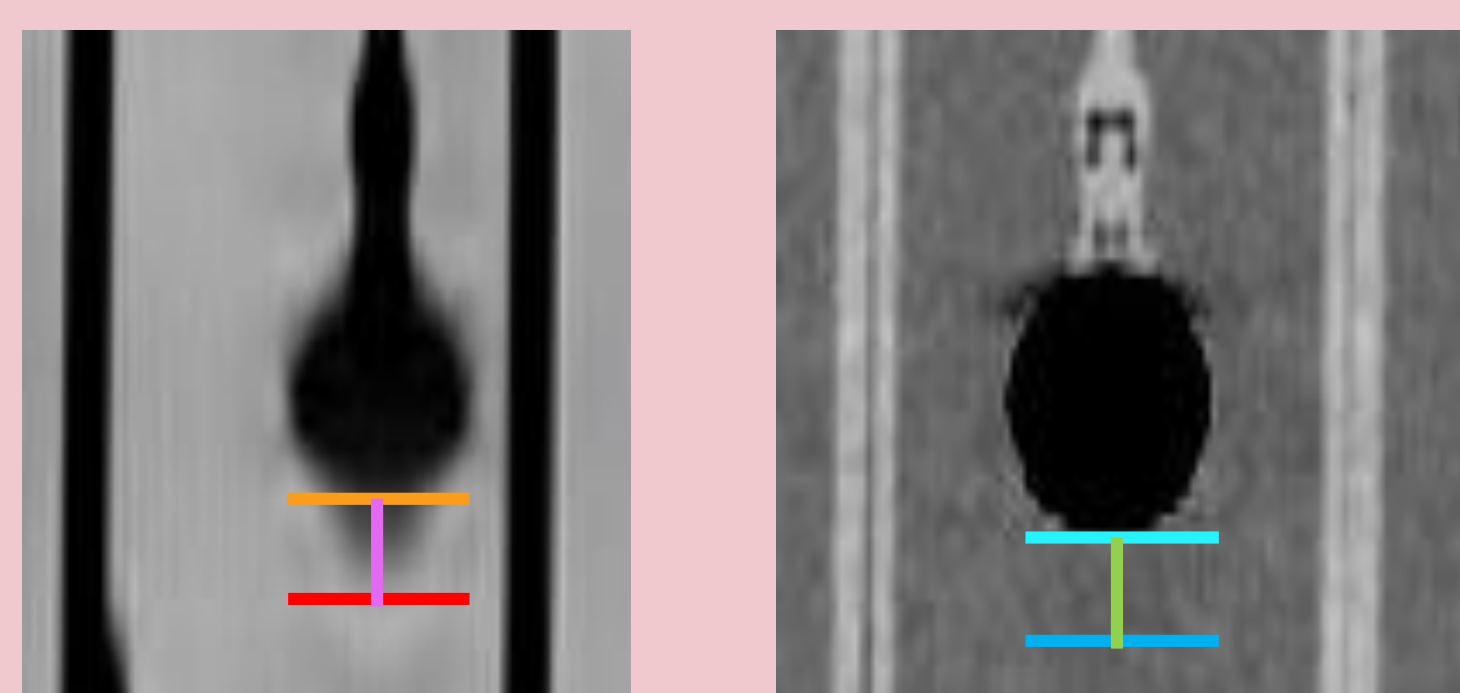
Waveform Types



- Sinusoidal waveforms with and without hysteresis were used.
- Absolute displacements fixed at 20 mm amplitude.

Figure 2: Example of phantom movement with (left) and without (right) hysteresis

Measurements

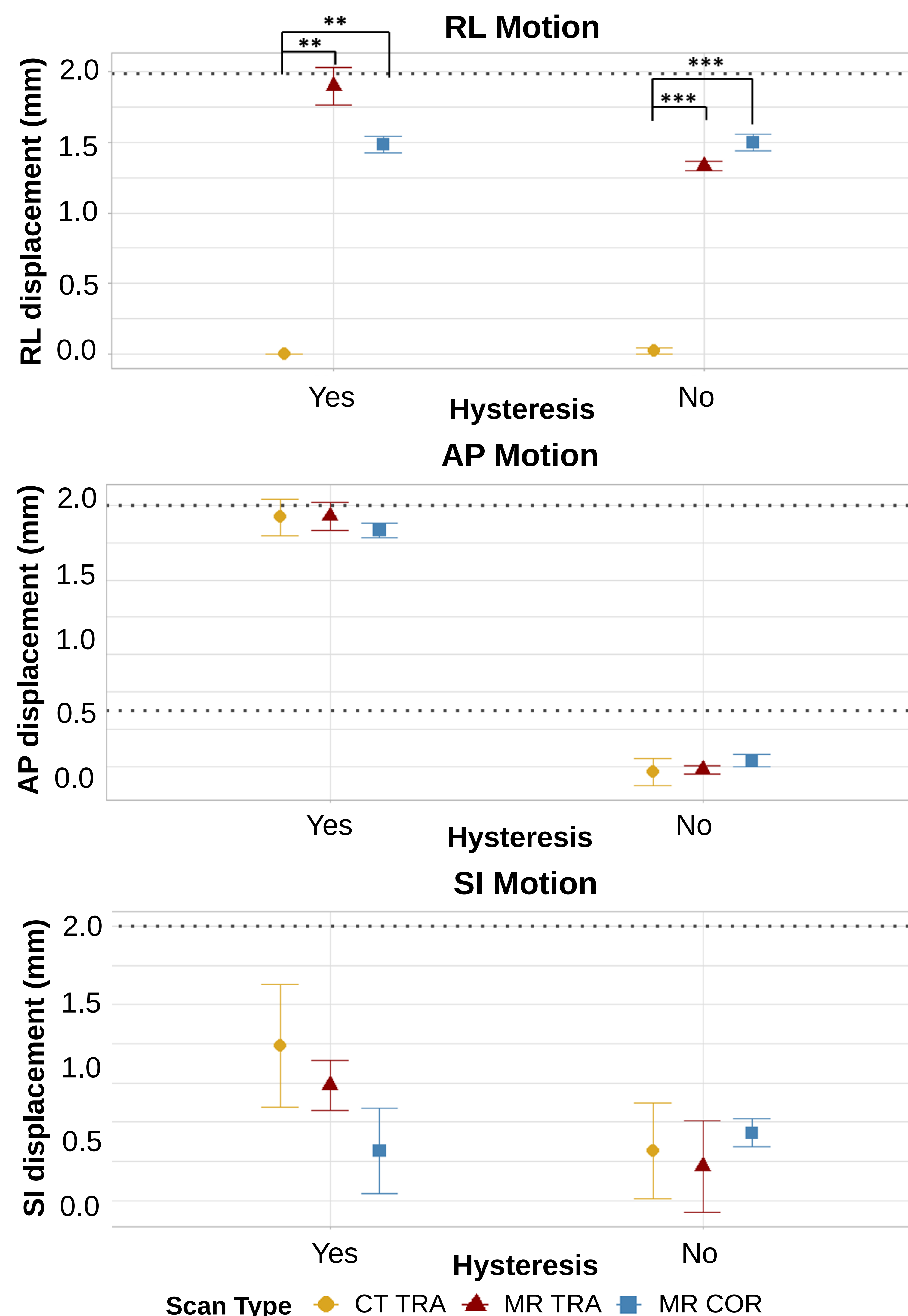


- Compare distances at maximum and minimum amplitude bin for each direction.
- Displacements were measured against the waveform maximum values.

Figure 3: Examples of measurements for an MR [left] and a CT [right] image with a hollow sphere.

Results

Displacement differences between CT and MR from three-dimensional sinusoidal waveforms



Measurements were evaluated with a Welch's ANOVA and Games-Howell test for differences and found to be different only for right-left motion. (** $p < 0.01$, *** $p < 0.001$).

Conclusions and Future Work

Conclusions

- Measurement similarity combined with improved soft-tissue contrast improving target delineation **supports 4D-MR as a potential substitute for 4D-CT** for abdominal patients undergoing MR-only adaptive radiotherapy.
- **MR performed better than CT for right-left motion** regardless of hysteresis.
- **Transverse MR acquisition has more accurate motion estimates for hysteresis waveforms** compared with coronal MR.

Future Work

- Change Gadolinium concentration and test accuracy.
- Run additional repetitions to improve statistics.

References

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