

# DESIGN AND VALIDATION OF AN ACCURATE, REPRODUCIBLE AND MR COMPATIBLE RESPIRATORY MOTION PHANTOM FOR USE IN CORONARY ARTERY AND GENERAL MR IMAGING

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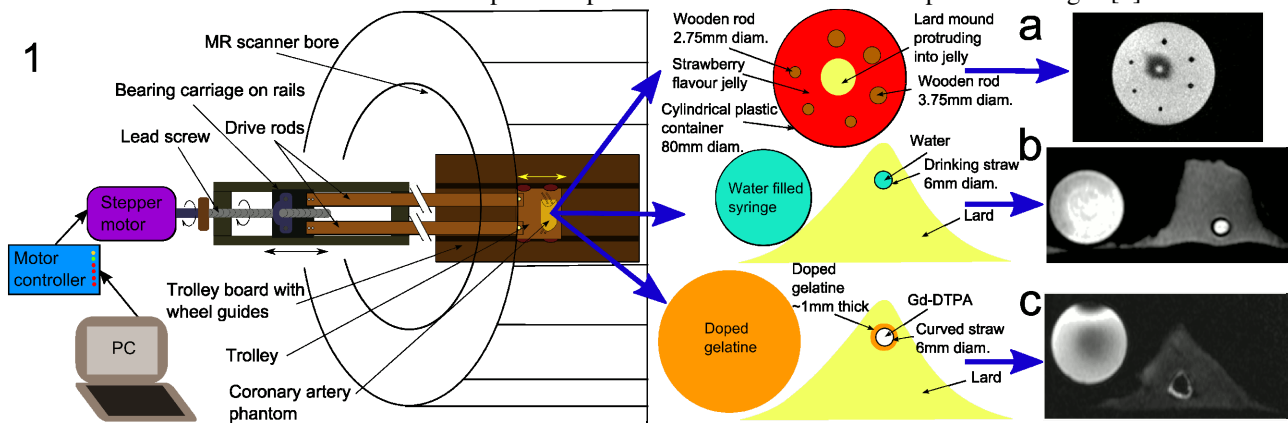
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## Introduction

Preliminary work on coronary vessel wall imaging demonstrated that non-model based correction of respiratory motion using 3D spiral fat-selective imaging [1] is feasible. This technique uses normalised sub-pixel cross-correlation (NSPCC) of low resolution 3D images of the fat surrounding the artery to derive and correct for respiratory motion on a beat-to-beat basis. Further development and systematic testing of the technique requires the development of an MR compatible respiratory motion phantom which can accurately and reproducibly follow physiological respiratory traces.

## Methods

**Design and construction:** Fig. 1 shows the phantom schematically. A microstepping controller drives a stepper motor. A lead screw converts rotary motion and drive rods push a trolley in tracks in the scanner bore. The drive rods maintain a safe distance between the ferromagnetic parts and the magnet. An optical switch mechanism cuts power at the extremes of motion for safety. The trolley can carry a range of test objects including (a) resolution phantoms and coronary artery lumen (b) and vessel wall (c) phantoms. Simulated or *in vivo* acquired respiratory traces with 25ms sampling period are followed using in-house software written for the controller in a variant of BASIC. The result is compact and provides smoother motion than previous designs [2].



**Validating the phantom:** Tests were performed on a Siemens Avanto 1.5T scanner. The phantom followed (a) a sinusoid (period 6s, amplitude 12mm) and (b) a respiratory trace obtained from a healthy subject using a diaphragmatic navigator (repeat time ( $T_R$ ) 200ms) interpolated to 25ms samples. Phantom displacement was measured using a conventional cross-pair navigator ( $T_R=100$ ms) positioned on the flat face of a gelatine cylinder placed on the trolley.

**Validating the normalised cross-correlation technique:** The test object in 1.b), oriented at  $30^\circ$  to the main field was imaged using the technique described in [1] with the imaging plane perpendicular to the vessel, whilst the phantom was stationary and when following the trace in 2.b). The phantom displacement in each simulated cardiac cycle (period 1000ms) was determined using 3D NSPCC of the low resolution fat images and used to correct the high resolution data acquired immediately after.

**Results**  
**Validation of the Phantom:** Fig. 2 compares driving waveforms and measured displacements for (a) sinusoidal and (b) *in vivo* acquired respiratory motion. Both traces were followed accurately and consistently (RMS error = 0.22mm - 1.8% and 1.6% of amplitude respectively).

**Validating the normalised cross-correlation technique:** Fig. 3 shows the high resolution water-only image of the phantom in 1.b) stationary (a) and following the trace in 2.b). The image in (c) is after in-plane and through-plane correction using the results of NSPCC of the low resolution fat images.

## Conclusion

An accurate, reproducible and MR compatible respiratory motion phantom including realistic coronary artery test objects has been developed for use in developing the non-model based respiratory motion correction technique. The phantom will be useful in assessing the effects and developing solutions to the problems caused by respiratory and possibly cardiac motion in various applications of MRI.

## References

- Keegan J. JMRI 2007; 26: 624-629.
- Jhooti P. MRM 1999; 41: 555-562.

