

## Background & Objectives

- FCMR offers complementary congenital heart diseases (CHD) diagnosis alongside ultrasound in 75/1,000 births.
- Unpredicted fetal motion causes up to 10 mm translation and 15° rotations, corrupting cine reconstructions and Dopple gating signal.

Problem: No validated fetal phantom exists to benchmark fetal MoCo (jerk, jitter, kick) algorithms repeatedly.

### Objectives:

- Design and fabricate an MR-compatible fetal phantom of 34 weeks gestation motion.
- Implement hydraulic actuation producing controlled translation and rotation movement.
- Validate phantom motion performance against clinical FCMR acquisition sequences with acquisitions at 1.5T.

## Prototype Design

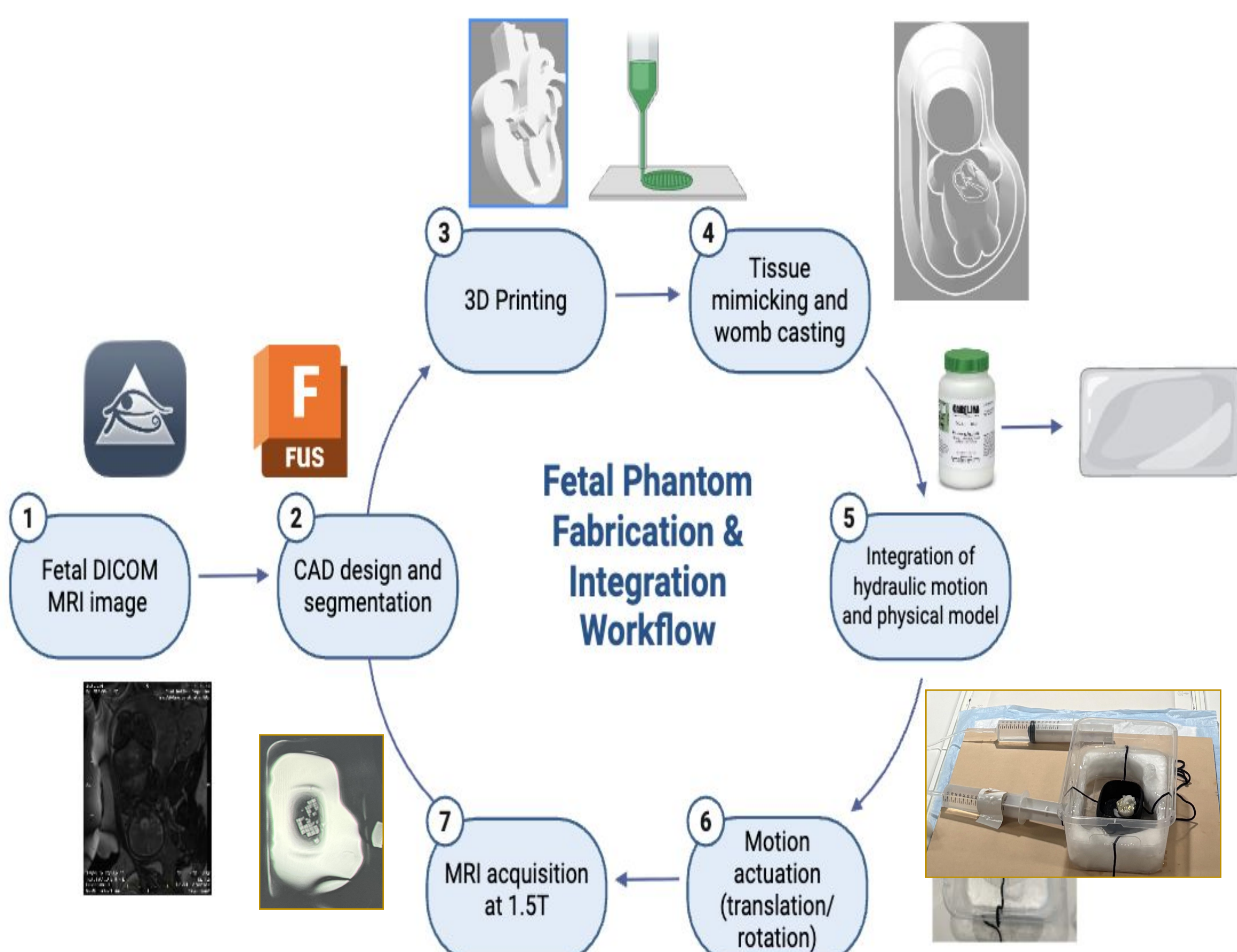


Figure 1. Fetal phantom for motion fabrication workflow from DICOM segmentation to 1.5T acquisition.

### Subproject 1 & 2: CAD Design and Tissue Mimicking Components

- DICOM segmentation
- 3D printing: PLA (rigid), TPU (flexible)
- Negative mold for PVA hydrogel casting into pear-shaped womb

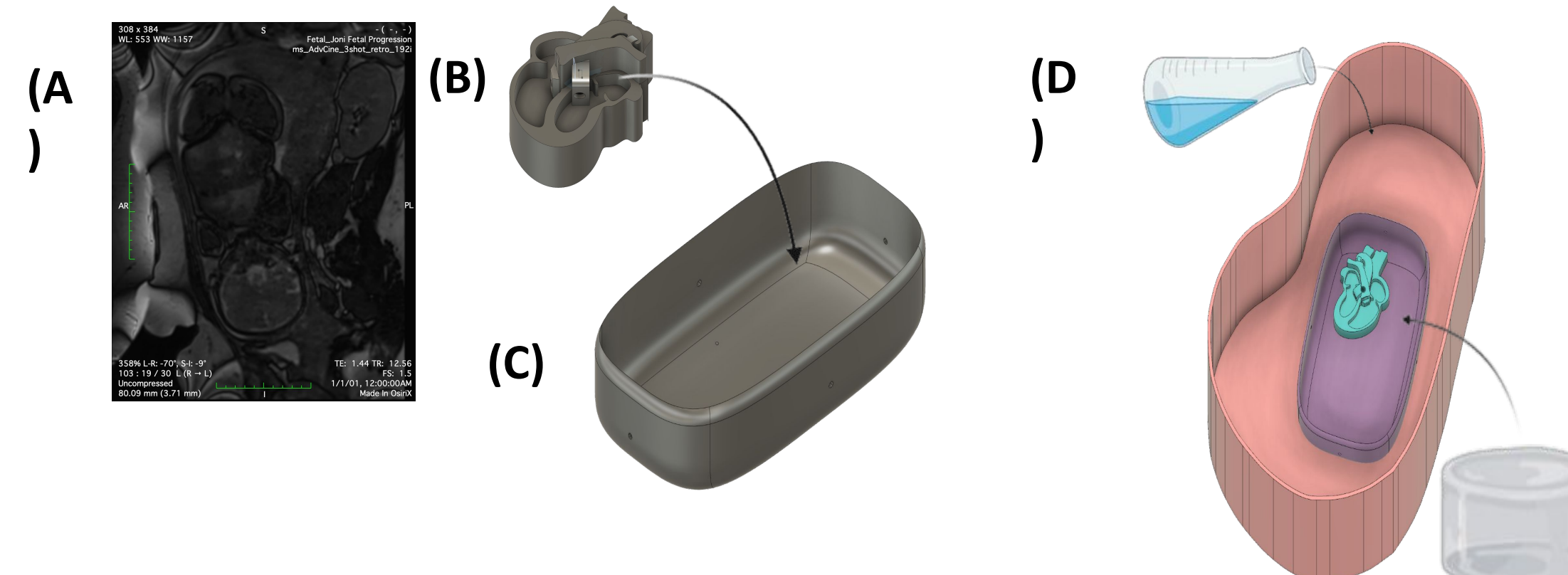


Figure 2. (A) Fetal DICOM MRI scan, source for anatomical segmentation. (B) 3D-Printed PLA fetal heart. (C) TPU torso (attached fetal heart). (D) Assembled womb ready for PVA freeze-thaw cycling and isotonic fill.

### Subproject 3: Simple Hydraulic Motion System



Figure 3. Visual Setup of the Hydraulic Motion System

### Subproject 4: Motion Acquisition at 1.5T

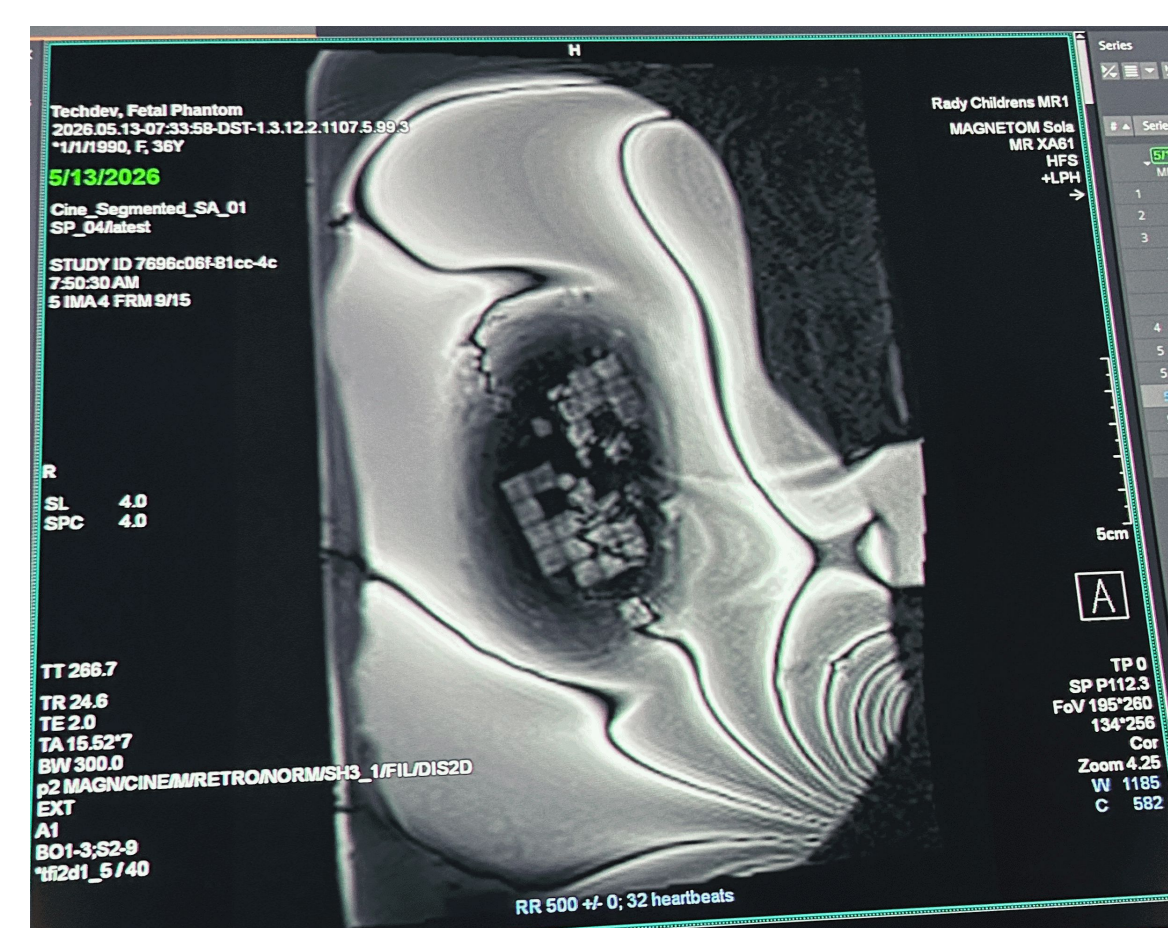


Figure 4. Cine Segmentation of Phantom using HASTE and SSFP sequences during 16 second Maternal Breathing Hold

### Validation:

- Controlled displacement confirmed
- Motion remains consistent across cycle
- Banding artifacts

## Expected Outcomes

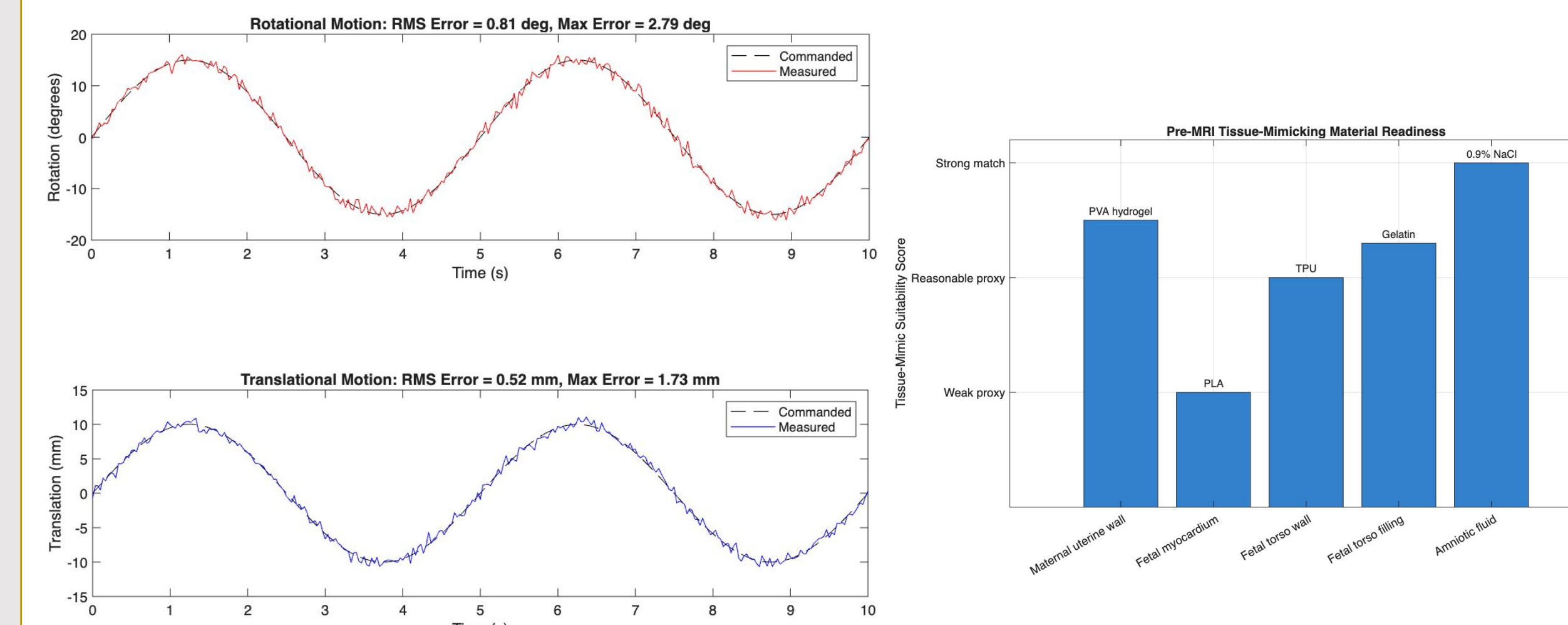


Figure 5. Controlled translation and rotational motion variability

Figure 6. Anatomical Match of Phantom Tissue-Mimicking Materials

## Future Directions

- Conduct quantitative MRI (1.5 T/3T) to distinguish T1/T2, signal-to-noise ratio (SNR), and artifact profile in relation to in-vivo fetal datasets
- Model limb and joint modules with anatomically accurate inserts with PVA-hydrogel casings to mimic fetal tissue elasticity and relaxation
- Integrate PID-controlled stepper motors for programmable translation and rotation

## Acknowledgements & References

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References