MRI Phantom Final Report

Members:
Layla Sheehan
Darrah Handmaker
Ava Kunesh

Introduction

Medical imaging phantoms are important tools in the biomedical imaging field. They serve as substitutes for human tissues, and are used to test various aspects of MRI machines. Anatomical phantoms are designed to replicate human body parts. They test the performance and accuracy of medical imaging machines. Resolution phantoms, on the other hand, assess the spatial and contrast resolution of imaging machines. Our group aims to design both a resolution and an anatomical phantom. Our anatomical phantom is designed to resemble a human finger, and our resolution phantom is designed to test the resolution of various materials and shapes.

Methodology

This outlines the methods used for creating a finger MRI phantom using an agar mixture for soft tissue and 3D printer filament as bone and skin. We had two different phantoms: anatomical and resolution.

1. Design & Planning

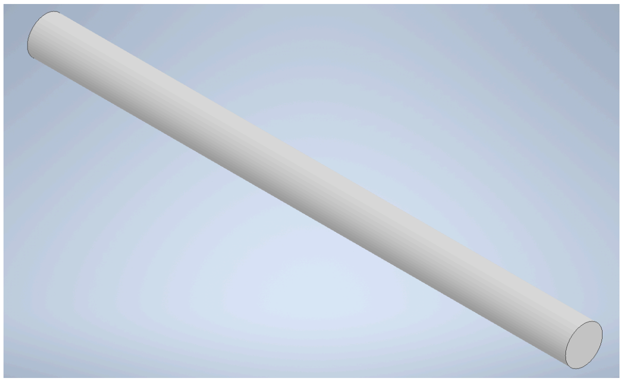
   1.1. Anatomical Reference

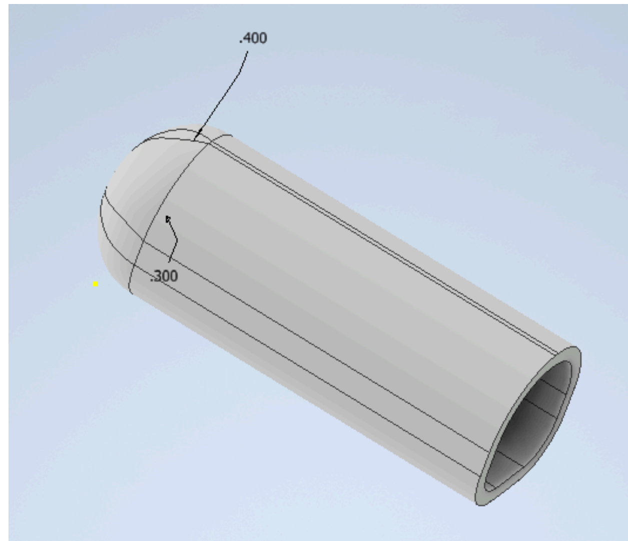
   - Procedure:
     - Acquire medical scans (MRI) of human finger
     - Model aspects of human finger: skin, bone, soft tissue

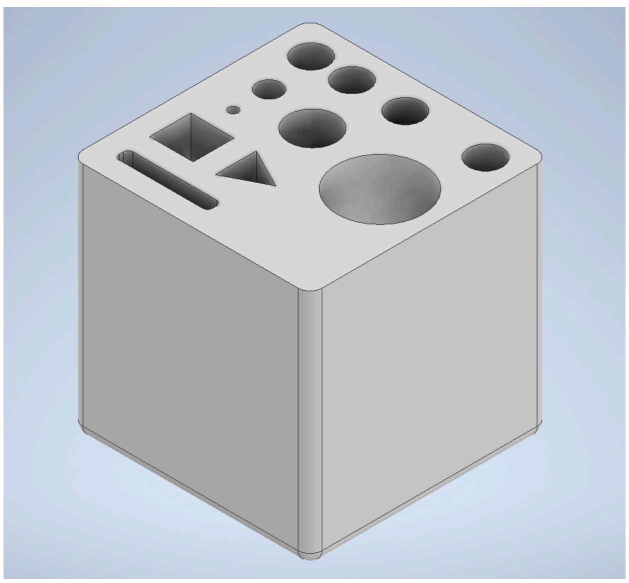
   1.2. Model Preparation

   - Software: AutoDesk Inventor Pro used to create 3D models.
     - Bone
     - Finger “shell/skin”
     - Cube resolution phantom
   - Assembly

- We will put the bone inside the finger and fill it with our agar mixture to mimic soft tissue. We will also fill the holes in the resolution cube with the agar mixture.







2. Material Selection

   2.1. Skin and Bone Simulation

   - 3D Print Material: We used 3D print plastic filament to mimic skin and bone

   2.2. Soft Tissue Simulation

   - Using an agar mixture

Usage	Material
Tissue	Agar mixture
Bone	3D printer filament
Skin/coating	3D printer filament

3. 3D Printing

- Printed finger as two separate pieces:
  - Skin - cylinder-like model 3in. in length and at most 1in. in diameter
  - Bone - basic cylinder that fit inside "skin" shell with plenty of room
- Also printed a resolution model that is shaped like a 2.5in. cube with 2in. wells of different shapes, sizes, and distances apart

4. Soft Tissue Injection

4.1. Preparation

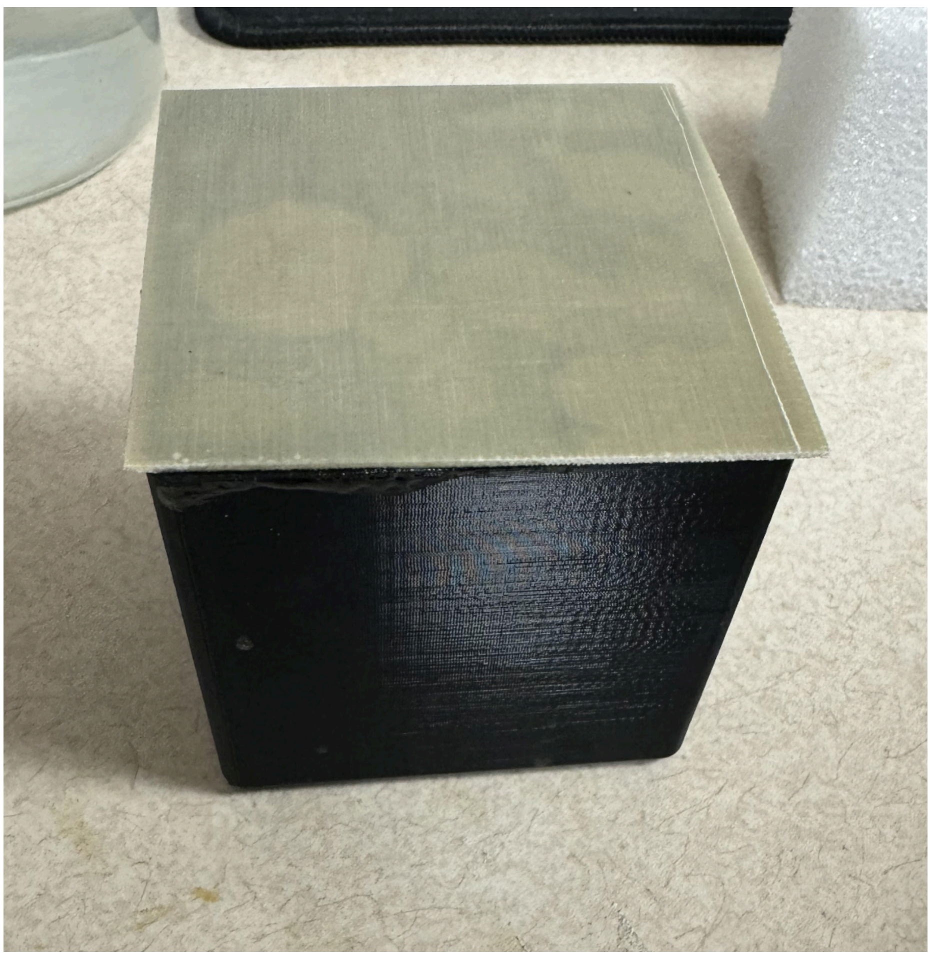
4.1.1. Anatomical Model

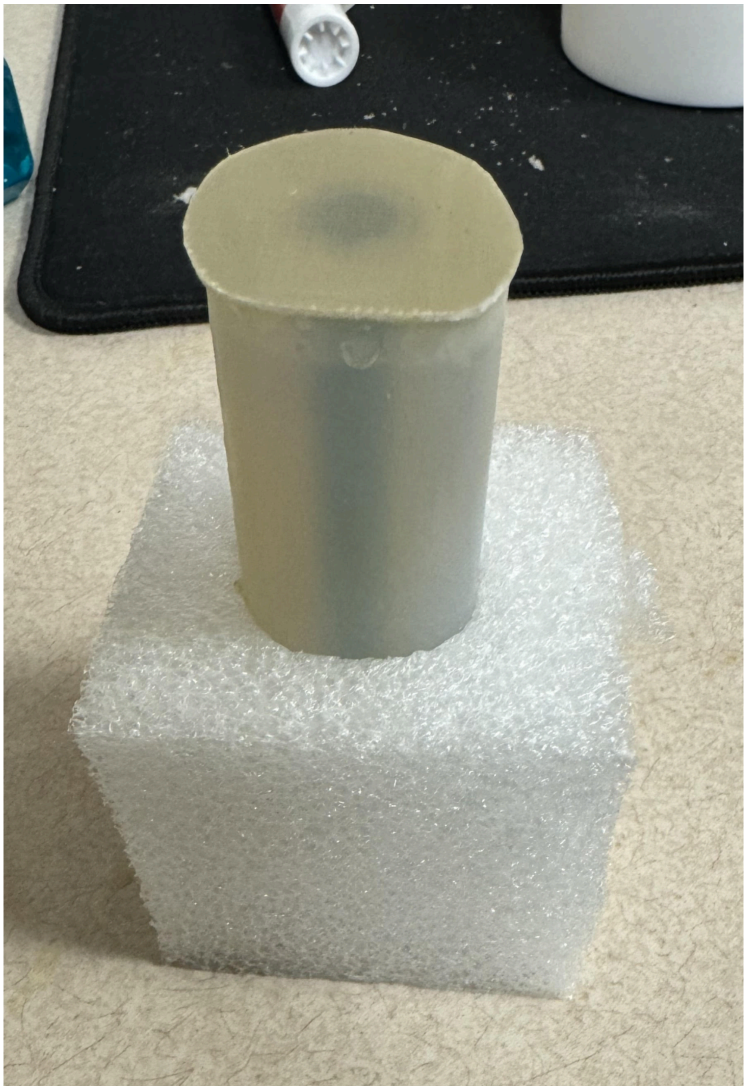
- We filled our anatomical model solely with a mixture of 5 grams of agar powder mixed with 95 grams of water and a little bit of Listerine, used as a preservative. We heated this mixture until it became transparent and poured this into our finger mold. We then attached the "bone" using resin.

4.1.2. Resolution Model

- For our resolution model we filled some of the holes with the same agar mixture as used before, but we also filled some holes with mineral oil and others with doped water. (pictured below)


water
agar
water
agar
agar
water
oil
water
agar
mineral oil





5. Testing and Validation
    - Though our phantoms are meant to test the capability of the MRI upon a scan, that scan, if it is determined to be high-quality, is likewise a test of our phantom design. Ideally, our materials and assembly provide strong contrast measurements for the image to have clear boundaries.
6. Documentation and Future Use
    - We saved our CAD files and other measurements used to create these phantoms so they could be easily referenced and the procedure repeated.

Discussion

Our anatomical phantom was just slightly larger than most life-size fingers, making it slightly inaccurate in terms of size. The walls were also quite thick, because we chose not to risk the fragility of a thinner 3D-print. In the end, the anatomical model represented a real finger very roughly, and improvements could be made to our model to make the shape, size, and details of both the shell and bone more representative of an actual human finger. This improvement in modeling would help us interpret the specificity of our MRI, and pinpoint methods of improvement for the scanner as a whole.

Our resolution phantom is made to test different shapes, sizes, and materials within the scan, which is helpful for determining what aspects of the MRI are functioning at a high level or not. However, in order to reduce the amount of confounding variables, in future developments it could be helpful to have multiple resolution phantoms that each vary one characteristic, so that differences can be more obviously attributed to one thing.

Results

Our anatomical and resolution models were successfully designed and assembled to test the imaging capabilities of the low-field MRI. The effectiveness of our phantoms in evaluating the capabilities of the MRI in distinguishing tissue- and bone-like substances is yet to be determined by a trial scan.

References

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