QIBA Phantom Preparation Instructions

I. INTRODUCTION

This phantom was developed to characterize MRI scanner performance when measuring the apparent diffusion coefficient (ADC).

In order to achieve reproducible ADC measurements, it is necessary to control the temperature of the phantom. An ice water bath serves to maintain temperature at 0°C. In the following sections, we will outline the phantom's various parts, as well as describe the proper procedures for phantom preparation and imaging.

II. PHANTOM PREPARATION

Diffusion is a thermally-driven process: as temperature increases, the apparent diffusion coefficients of the phantom solutions will also increase. The increase is on the order of 2-3 % per degree Celsius for DI water. It is therefore critical that temperature be consistent when scanning the phantom, a goal best achieved by the use of ice water. Please use the following procedure to equilibrate the phantom at 0°C, and maintain temperature during the scan.

Figure 1. Phantom after being in the refrigerator overnight. Add more crushed ice to displace any melted water in order to maintain a 0°C bath.

1. It is preferable to begin preparing the phantom the evening before the day of the scan by obtaining ice and slightly crushing it. If it is too finely crushed it may cause unavoidable air pockets in the imaging plane that will generate susceptibility induced artifacts. To gauge how much ice is needed, the phantom with components in it has a volume of approximately 2 L.
2. Fill the phantom with ice, once filled add cold DI water to the phantom. Place the phantom in the refrigerator overnight. *There should be more ice than water to ensure a proper ice water bath at 0 °C. The ice should not float; instead, water should fill the interstitial spaces formed by the ice.*
3. The next morning, remove the phantom from the refrigerator. Some of the ice will have melted, but there should still be some in the phantom (Figure 1). This does not mean that the phantom is at 0 °C. More ice will need to be added. Add more crushed ice to displace the water. Add enough ice to have a proper bath, where the ice does not float and water fills the interstitial spaces. If displacing the water is too difficult, you can drain the water into a pitcher with ice. Fill the phantom with as much crushed ice as possible, and pour the iced water back into the phantom to fill the interstitial spaces.

Figure 2. Assembled phantom. Secondary fill ports can be used to eliminate residual air bubbles.

4. In order to eliminate residual air bubbles in the phantom, one may add water to the phantom via the secondary fill ports. Create an ice water bath (as described above) in a medium-sized beaker. Use this liquid water from this beaker to top off the phantom via the secondary fill ports.

5. Before closing off the phantom's secondary fill ports, check the temperature of the phantom. The temperature displayed by the probe should read 0 ± 0.2 °C. It is a good idea to check both halves of the phantom, and to record these values.

Ideally, prepare the phantom at the end of day in anticipation of imaging it first thing the following morning. Once the phantom has been properly prepared, it should hold temperature for a few hours, long enough to accomplish scanning at 0°C. If overnight preparation is not possible, the phantom requires at least 2 hours to equilibrate to 0°C. Make sure to top off the phantom with ice before scanning to ensure the vials stay at 0 °C throughout the scan protocol and take temperature measurements before and after scanning.

III. PHANTOM IMAGING

When loading the phantom into the magnet, it is important that the center vial be aligned with magnet iso-center. Use padding to achieve the proper height and secure phantom in place. Protocols for imaging on various scanners are provided in the QIBA profile guidance document.

Initial Positioning:

1. Position phantom as shown in Figure . Note, location of serial# sticker.
2. Start new exam and enter subject as "Head First Supine"

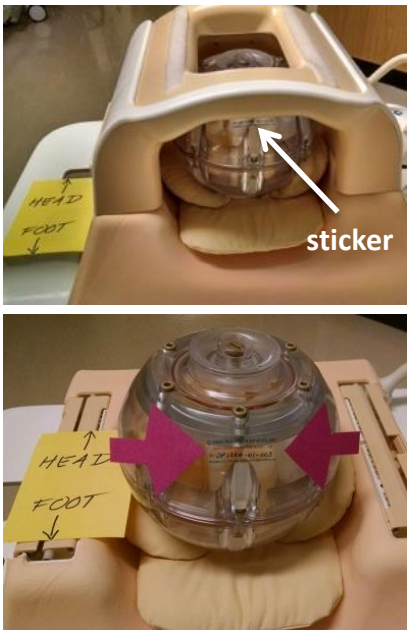


Figure 3. Coronal positioning

Coronal Set:

1. Acquire survey scan that includes CORONAL slices through phantom
2. See Figure 4 for representative coronal slice mid-phantom
3. Acquire "Pass 1" coronal DWI per protocols in Section V (allow full prescan adjustments)
4. Acquire "Pass 2, 3, 4" coronal DWI (with minimal prescan adjustments, i.e. just hit "scan" three more times)

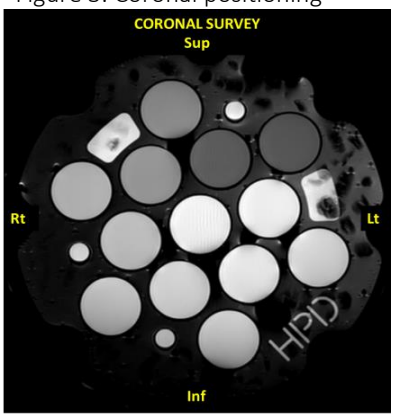
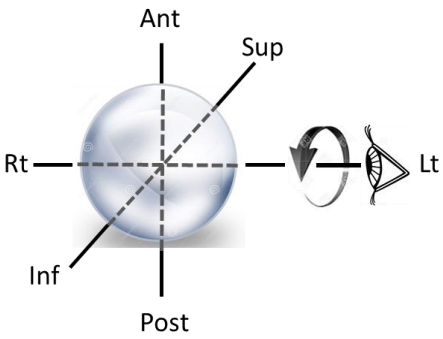


Figure 4. Coronal slice mid-phantom.

Axial Set (continue within the same exam):

1. Acquire survey scan that includes AXIAL slices through phantom
2. Physically rotate the phantom 90^{o} COUNTER-CLOCKWISE as viewed from a perspective looking from subject's LEFT-TO-RIGHT (see Figure a). The phantom should now look as in Figure b.
3. Acquire survey scan that includes AXIAL slices through phantom
4. See Figure c for representative axial slice mid-phantom
5. Acquire "Pass 1" axial DWI per QIBA protocol (allow full prescan adjustments)
6. Acquire "Pass 2, 3, 4" axial DWI (with minimal prescan adjustments, i.e. just hit "scan" three more times)



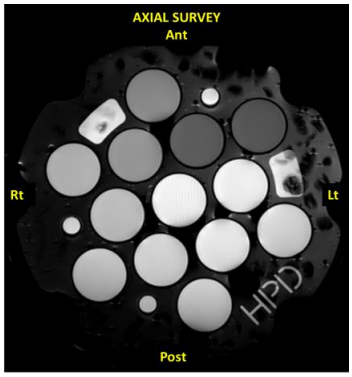


Figure 5. a) Diagram of perspective when looking from left-to-right. b) Image of phantom in axial imaging orientation. c) Axial slice mid-phantom.

Sagittal Set (continue within the same exam):

1. Acquire survey scan that includes SAGITTAL slices through phantom
2. *First* - Physically rotate the phantom 90° COUNTER-CLOCKWISE as viewed from a perspective looking from subject's ANTERIOR-TO-POSTERIOR (see Figure 6).
3. *Second* - Physically rotate the phantom 90° CLOCKWISE as viewed from a perspective looking from subject's LEFT-TO-RIGHT (see Figure 6). The phantom should now look as in Figure a. Acquire survey scan that includes SAGITTAL slices through phantom.
4. See Figure 7b for representative sagittal slice mid-phantom
5. Acquire "Pass 1" sagittal DWI per QIBA protocol (allow full prescan adjustments)
6. Acquire "Pass 2, 3, 4" sagittal DWI (with minimal prescan adjustments, i.e. just hit "scan" three more times)

After imaging, remove the secondary fill port screws in order to check the temperature of the phantom with the provided thermocouple. Record the post-imaging temperatures of both the top and bottom hemispheres. Remove the top fill port cap and dump the ice and water. Repeat for the bottom fill port cap. The phantom is now ready to be stored. When not in use, store this phantom dry and in a dry, dark, temperature controlled location (~20°C).

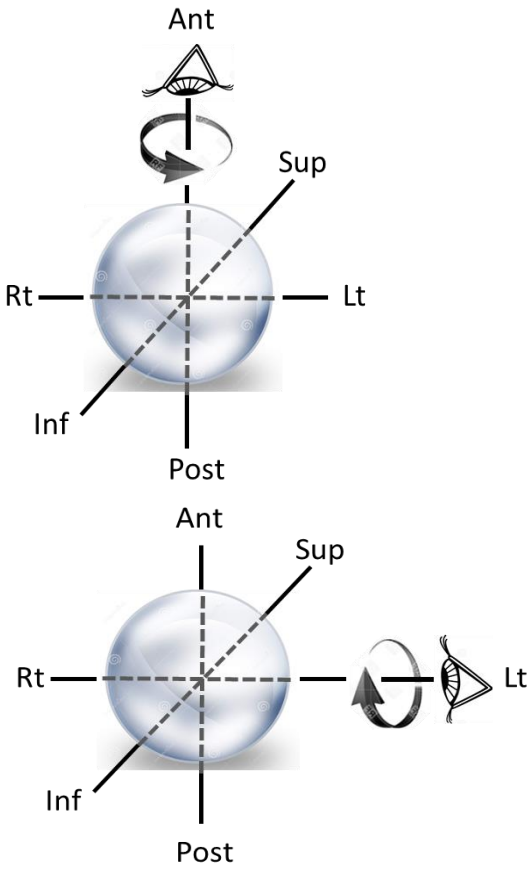


Figure 6. a) Perspective view A-P, rotate phantom 90° CW. b) Perspective view left-to-right, rotate phantom 90° CW again.

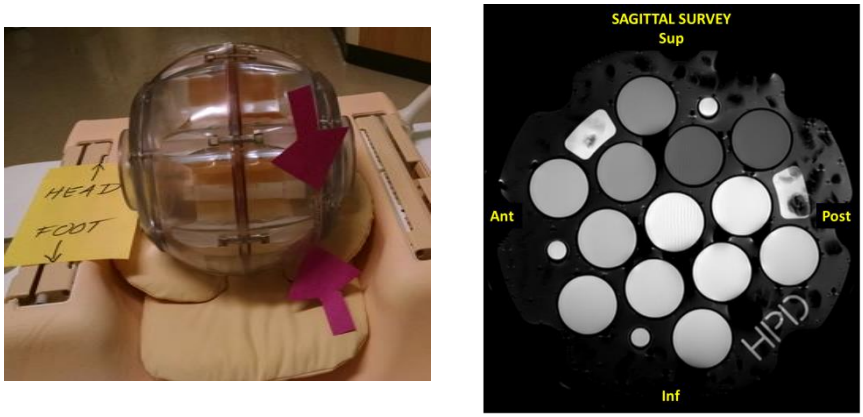


Figure 7. a) Image of phantom in sagittal orientation. b) Sagittal slice mid-phantom.