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MRI Geometric Distortion QA

Using the ACR MRI Accreditation Phantom

This document is a brief instruction on how the ACR (American College of Radiology) accreditation phantom can be used to evaluate geometric distortions in MRI for quality assurance (QA) purposes.

Please note that this document only gives a quick overview on the main workflow tasks in case you are already familiar with the procedure. If you are, however, using it for the first time please focus on the main manual for a detailed description and important notes.

Furthermore, the main manual shows principles, background information on geometric distortion and instructions for phantom holder fabrications.

Notes:

- Workflow

  The presented workflow is based on the provided sequences and suggested phantom holders. To customize this procedure to your own needs, please read the instructions in the main manual.

- Sequences:

  The provided protocols are TSE sequences for standard contrast. The grid positions are pre-set according to the setups presented on the next pages. If you want to use different setups or sequence parameters please follow the instructions on 'Customizing Sequences' in the main manual for important notes.

- Phantom holders:

  The presented holders for lateral positioning of the ACR phantom are suggestions for your own fabrication. Detailed descriptions can be found in the main manual.

  For vertical variation standard cushion phantom holders are suggested as can be found at every site.

- Results:

  Note that covering the whole field of view (FoV) is only possible in the coronal view. In the sagittal and transversal case only one row in one height can be combined since addition of images from different height settings is not possible.

Contents
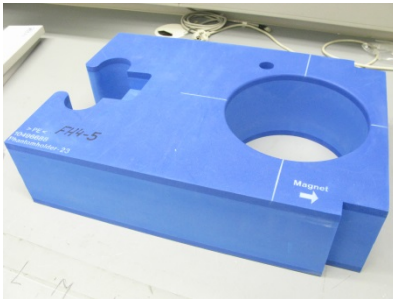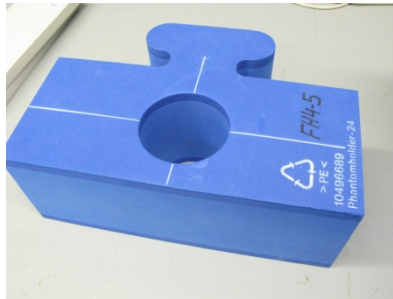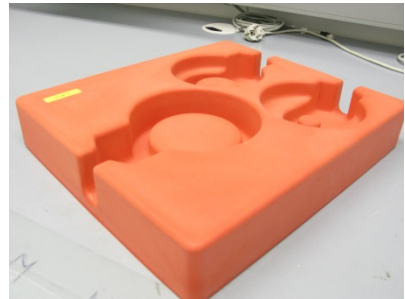
Materials
What you need:

1. The ACR phantom

2. A plate shaped holder for lateral positioning and fixation (own fabrication)

3. A bracket shaped holder to fixate the phantom for sagittal and transversal setups (own fabrication)

4. Standard cushion phantom holders for height variations

| Phantom holder 25 | Phantom holder 24 | Phantom holder 17 |

5. 2-3 (water) bottle phantoms to ensure for enough signal along with cushion holders for positioning

6. Standard cable-clips for fixation on the table

Positioning

-   Make sure the **body coil** is installed on your table.

The whole setup should be placed in the head region on the table.

On the next pages (4-6) you find an overview of all recommended positions for the coronal, sagittal and transversal case, respectively.
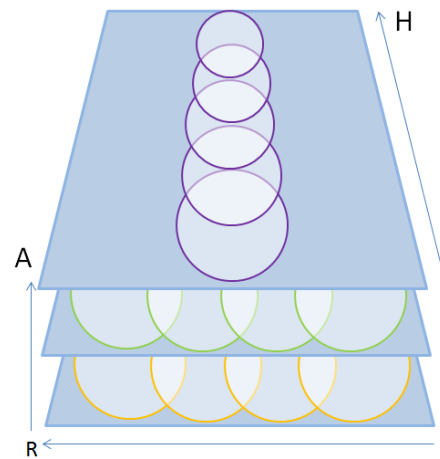
-   Based on these setups choose your first desired grid height and start with setting up the first lateral position according to the following notes.

Coronal

For the coronal setup you do not need the bracket shaped phantom holder.

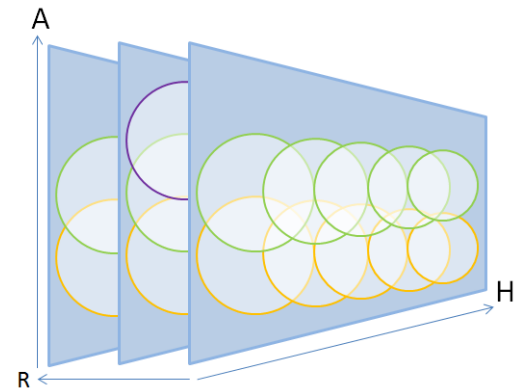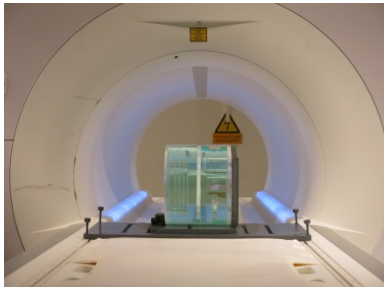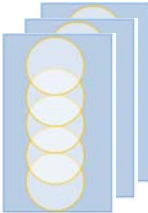- Place the phantom directly onto the plate shaped holder at the desired lateral position.
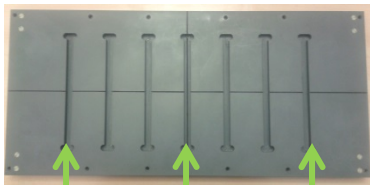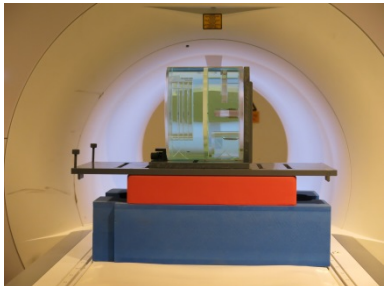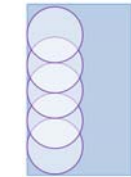
Vertical Setup/ Height Number	Lateral Positions	# of images to add up	Sequence Folder
1 **Grid height: ~8cm**	# of positions: 4 1 3 5 7	 **4x5**	Cor_Height1 (tse-cor-1-H180,...) 5 Sequences/ Table Positions **Same for all 4 lateral positions**
2 **Grid height: ~20.5cm**	# of positions: 4 1 3 5 7	 **4x5**	Cor_Height2 (tse-cor-2-H180,...) 5 Sequences/ Table Positions **Same for all 4 lateral positions**
3 **Grid height: ~33cm**	# of positions: 1 4	 **5x1**	Cor_Height3 (tse-cor-3-H180,...) 5 Sequences/ Table Positions

Sagittal

- Use the 'sagittal side' of the bracket-shaped phantom holder to stabilize the phantom.

- Place both together onto the plate shaped holder.

Note: place the bracket shaped holder as presented below with the open side to your left to match the pre-defined positions in the protocols.
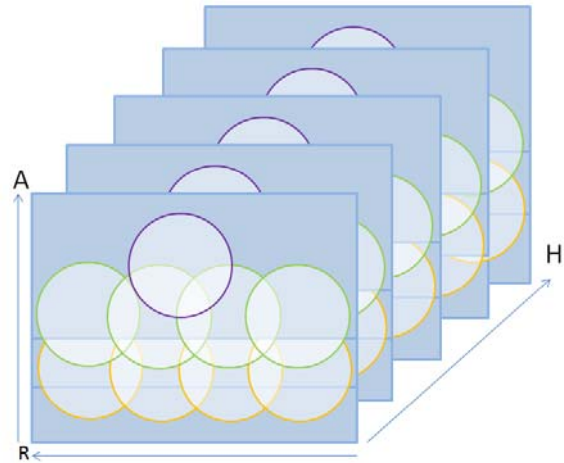

Vertical Setup/ Height Number	Lateral Positions	# images to add up	Sequence Folder
1 Grid height: ~4.5-19.5cm	# of positions: 1 4 7	(3x) 5x1	Sag-Height1/P1, Sag- Height1/P4, Sag- Height1/P7 (tse-sag-Pos1-H180,…) **3 Lateral Positions** 5 Sequences/ Table Positions each
2 Grid height: ~16.5-31.5cm	# of positions: 3 1 4 7	(3x) 5x1	Sag- Height2/P1, Sag- Height2/P4, Sag- Height2/P7 (tse-sag-Pos1-H180,…) **3 Lateral Positions** 5 Sequences/ Table Positions each
3 Grid height: ~22.5-37.5cm	# of positions: 1 4	(1x) 5x1	Sag- Height3/P4, (tse-sag-Pos1-H180,…) **1 Lateral Position** 5 Sequences/ Table Positions each

Transversal

- Use the 'transversal side' of the bracket-shaped phantom holder to stabilize the phantom.

- Place both together onto the plate shaped holder.

Note: In the transversal case (in contrast to coronal and sagittal) the 5 images acquired in one lateral position belong to 5 slice sets and not to one final image. Each slice set will be completed after completing all lateral positions.


| Vertical Setup/ Height Number	Lateral Positions	# images to add up	Sequence Folder
1 Grid height: ~4.5-19.5cm	# of positions: 4 1 3 5 7	 (5x) 1x4	Trans_Height1 (tse-trans-1-H180,...) 5 Sequences/ Table Positions **Same for all 4 lateral positions!**
2 Grid height: ~16.5-31.5cm	# of positions: 4 1 3 5 7	 (5x) 1x4	Trans_Height2 (tse-trans-1-H180,...) 5 Sequences/ Table Positions **Same for all 4 lateral positions!**
3 Grid height: ~22.5-37.5cm	# of positions: 1 4	 (5x) 1x1	Trans_Height3 (tse-trans-1-H180,...) **1 Lateral Position** 5 Sequences/ Table Positions Single image, no adding up

- Make sure the plate shaped holder is fixated with the guidelines when choosing the setup right on the table. For positioning on top of cushion holders align the plate with the cushion edge.

- Fixate the holder with the cable-clips on the table so it doesn't move during re-positioning

- **Balance** the phantom with the adjusting screws on the holder using the water levels for control. Always re-balance after moving the phantom.
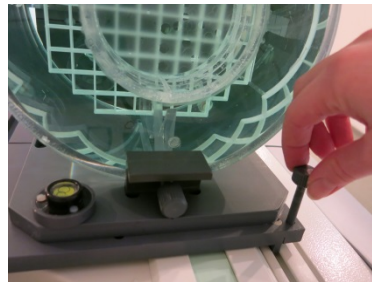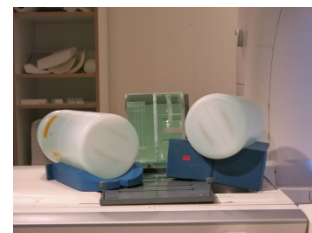

- Place **additional water-bottle phantoms** to ensure enough signal. Note: do not place the bottles in the same plane as the grid. If the bottles are lying on the holder, rebalance the phantom again. Examples:
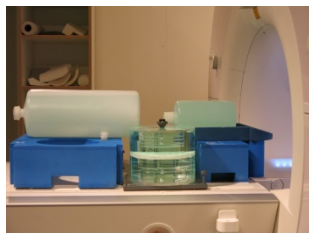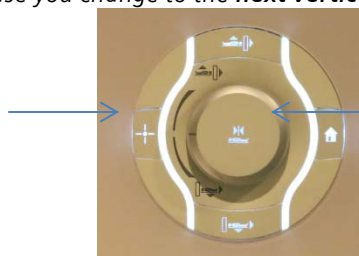

| Coronal | Sagittal | Transversal |

- Align the markings on the plate shaped holder with the **laser crosshairs** of the scanner.

- Move this position to the iso-center of the scanner by pressing and holding the table positioning button. *Note: If you **change lateral positions** after finishing scanning one position you **must not** align the position with the laser cross again or move the table to the iso-center. The position is still saved and will be reached automatically. In case you change to the **next vertical position** you need to align again.*
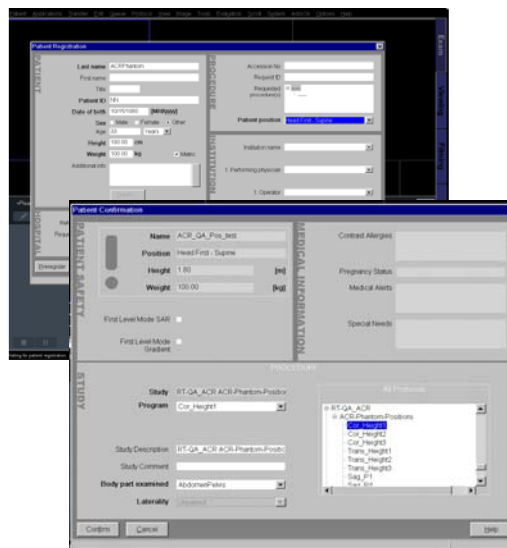

Activating laser cross → ← Press and hold to move table to iso-center

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Measuring

- Import the protocol set.

- Register a new patient and choose the patient position to be **Head-first supine.** Choose the protocols according to your setup (see the column 'Sequence folder' in the overview above).

- Drag all sequences in the chosen folder (according to the setup) into the queue on the left.

  *The measurement will start automatically with a **localizer**. Check if the slice positions really fit the grid position.*
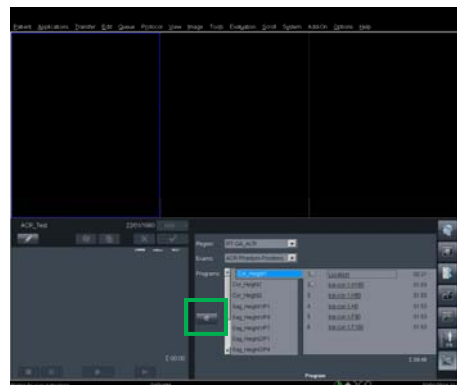
- **Start the measurement**

  The measurement will automatically be repeated for 5 different table positions.

  ***Note:** If the scanner doesn't run you might need to re-position the bottle phantoms accordingly to ensure enough signal in the iso-center of the scanner at each table position.*

- When scanning is completed for this position **set up the next lateral phantom position** according to the instructions above.

  Note: Be careful! Do not move or twist the position of the phantom holder(s)!

  Use the same registered patient for all measurements.

- **Restart the measurement**

  o *For the **coronal and transversal** case: Restart the same protocols as before (right-click on first sequence: 'Rerun from here')*

  o *For the **sagittal** case you need to choose a new set of protocols according to the new lateral position*

- After finishing all necessary or desired lateral positions the final **images can be assembled** (see Image assembly).

- For measuring **a different vertical position** start from the beginning.

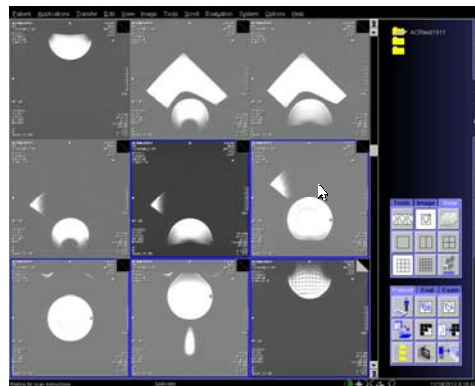 *Note: Measurements from different vertical positions cannot be combined.*
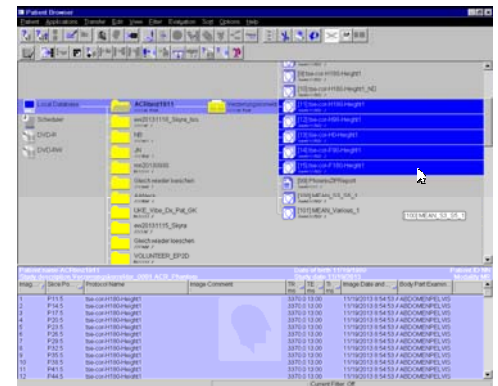
Image Assembly

a)   b)

- Highlight all image stacks (a) in the viewer or (b) in the image folder that belong to one plane using the CTRL button.

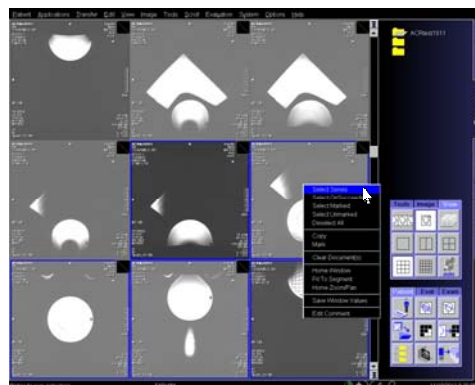 *(see overviews for number of images that should be highlighted to be added up)*
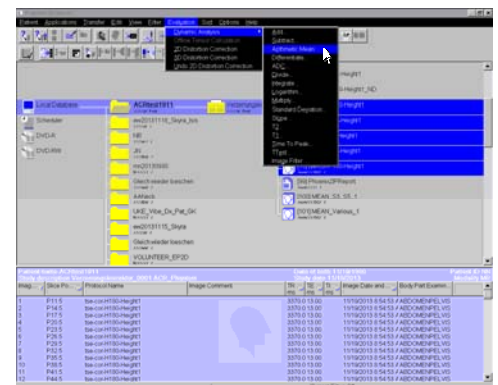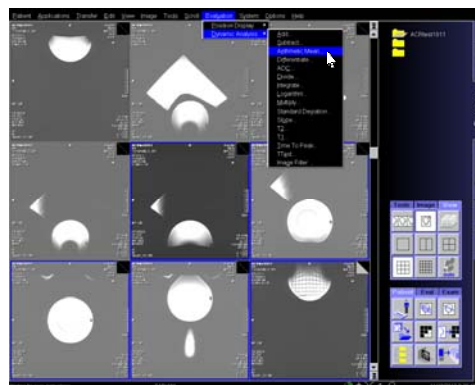

- In case (a): Choose the whole stack by right-clicking on the marked images and selecting '*Select Sequence*'.
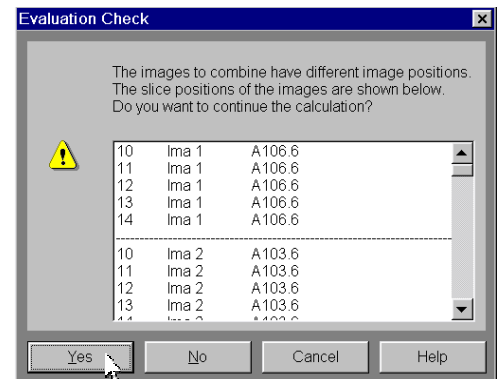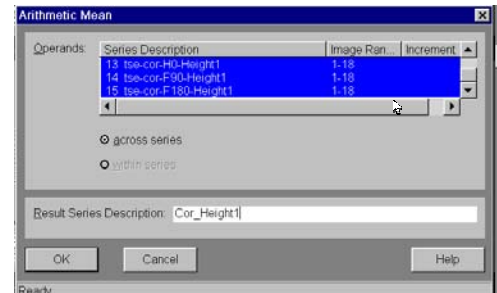

- Go to '*Evaluation*'

- open '*Dynamic Analysis*'
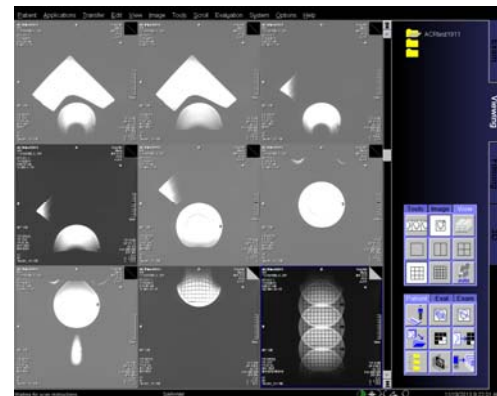
- Choose the '*Arithmetic Mean*'.

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- Select all the shown image stacks using CTRL. Select a name for the resulting series (e.g. Coronal_Height1).

- *In the coronal and sagittal case: The appearing warning tells you that each image has a different image (tabel) position, respectively.* Click *Yes.*
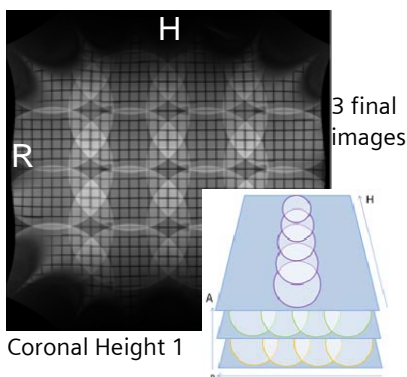

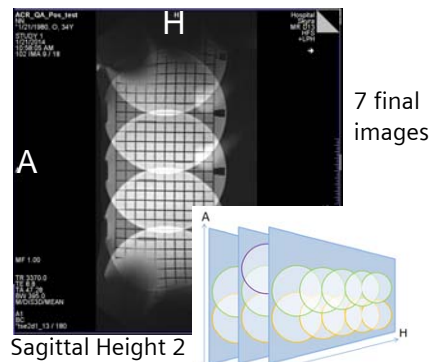*After a short calculation time a new image stack is shown in the viewer covering the whole FoV in one plane.*
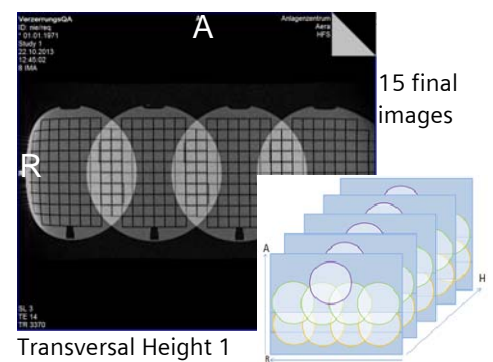

Desired Results: Examples

Coronal

3 final images

Coronal Height 1

Sagittal

7 final images

Sagittal Height 2

Transversal

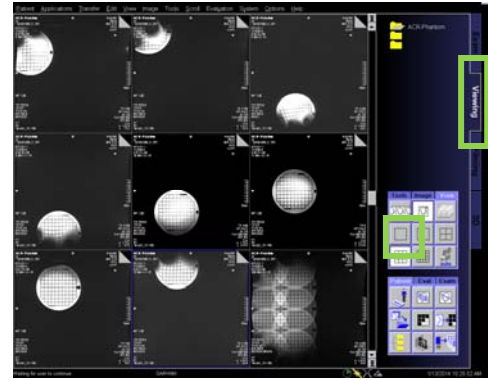15 final images

Transversal Height 1
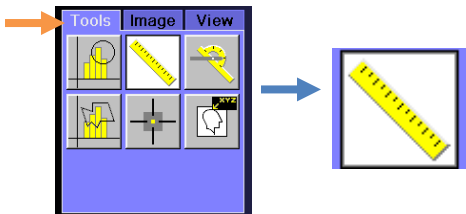
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Evaluation

'By hand' evaluation using the built-in measurement tool
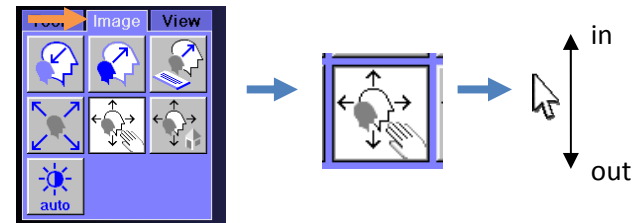
- Go to the '*Viewing*' screen and open your acquired final image

- **For distance measurements activate:**

To zoom in activate:

Tips:

- You can start evaluation of a completed image while already scanning the phantom in another position or orientation to save time.

- Note that measuring larger distances on the screen rather than short ones reduces the absolute error you generate in your measurement:

  Either measure over a large grid area to estimate the overall distortion in one direction,

  or zoom in for more precision in a smaller part of the grid

- Repeat measurements to estimate your own measuring error.

- Either measure from edge to edge (1) or mid to mid (2) of the grid bars, the ideal grid has a **spacing of 1.5cm**.

- Use diagonal measurements (3) to catch the total distortion in x- as well as y-direction, use the intersections of the grid bars as marker points.

- **Note:** The drawn measurements are not saved in the final image!
  Tip: **Screenshots** during evaluation at the scanning site
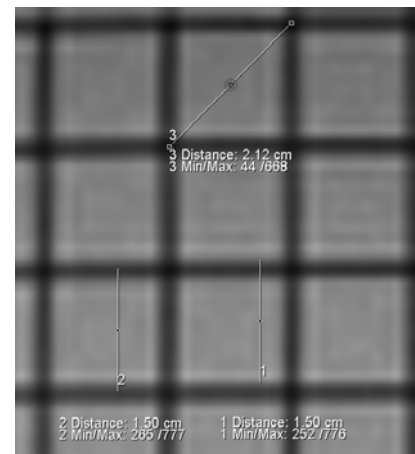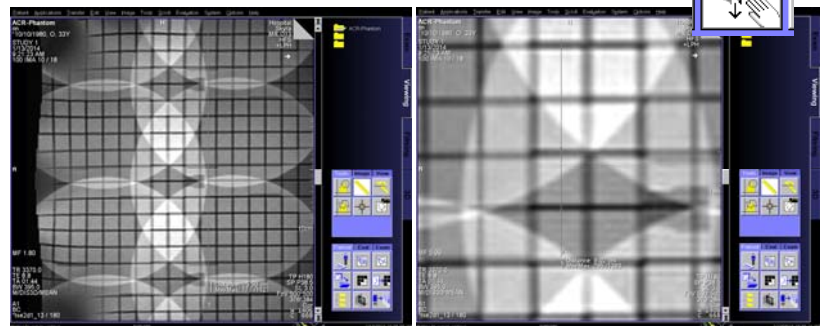
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