A simple soft tissue phantom with randomizable low contrast features for use in CT and MRI - Part I: Design and verification

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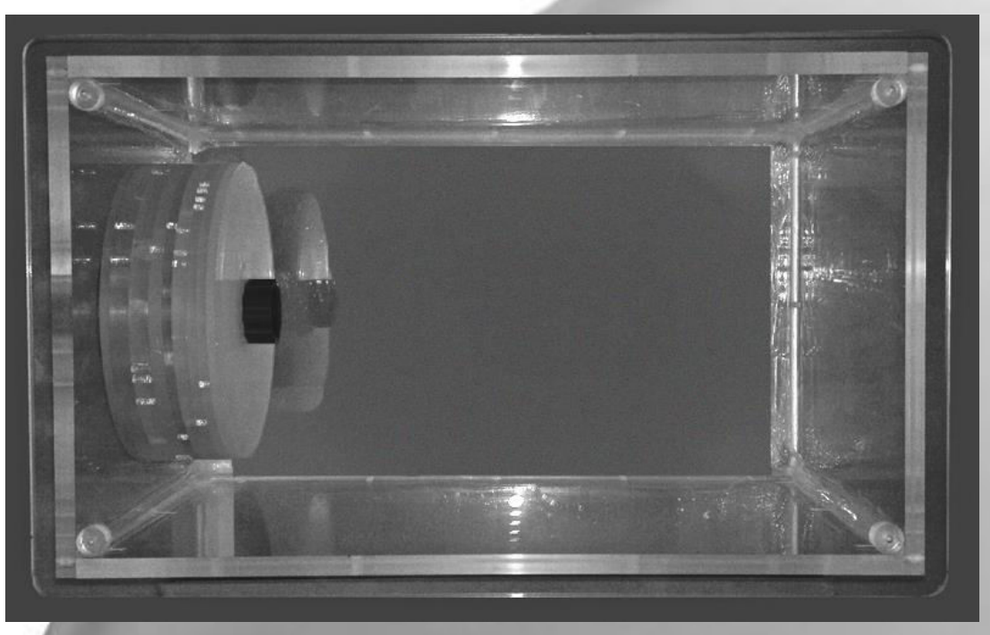

Figure 1. Photographic top view of the phantom.

Background

Multidetector CT (MDCT) has led to improvements in lesion detection, but there is a radiation dose cost to the patient. To examine dose reduction methods an appropriate test phantom is required for feasibility studies and to avoid unnecessary patient exposure.

Purpose

A soft tissue phantom with randomizable low contrast features was designed to investigate the detectability of liver lesions with CT, which would avoid any learning effect during evaluation by radiologists. The phantom was also designed to be suitable for use in MRI studies.

Methods

The phantom was constructed using Poly(methyl methacrylate) (PMMA) with a radiodensity of 120 HU, which was of the correct order of magnitude for soft tissues that include the liver. PMMA was also selected as the material of choice as it was cost-effective, easy to work with and to maintain. The test phantom was constructed using a series of seven PMMA discs. The discs were housed inside a PMMA tank with a lid, shown in the photograph in Figure 1. The feature discs contained a series of holes and disc positions were randomizable by rotations between scans. (Feature disc 1 is the background image.) The holes with differing diameters and paths through the disc were arranged in random but known locations. Relatively low contrast features could then be simulated by filling the tank with suitable contrast media mixed with water. A spatial resolution disc was also included for image quality reporting.

To verify if the test phantom was fit for purpose in CT, high contrast and low contrast feature images were sought. To explore the suitability of the test phantom for low contrast feature imaging in MRI the phantom was again scanned with the discs in water. The imaging tests, (a) to (c), are described by Table 1.

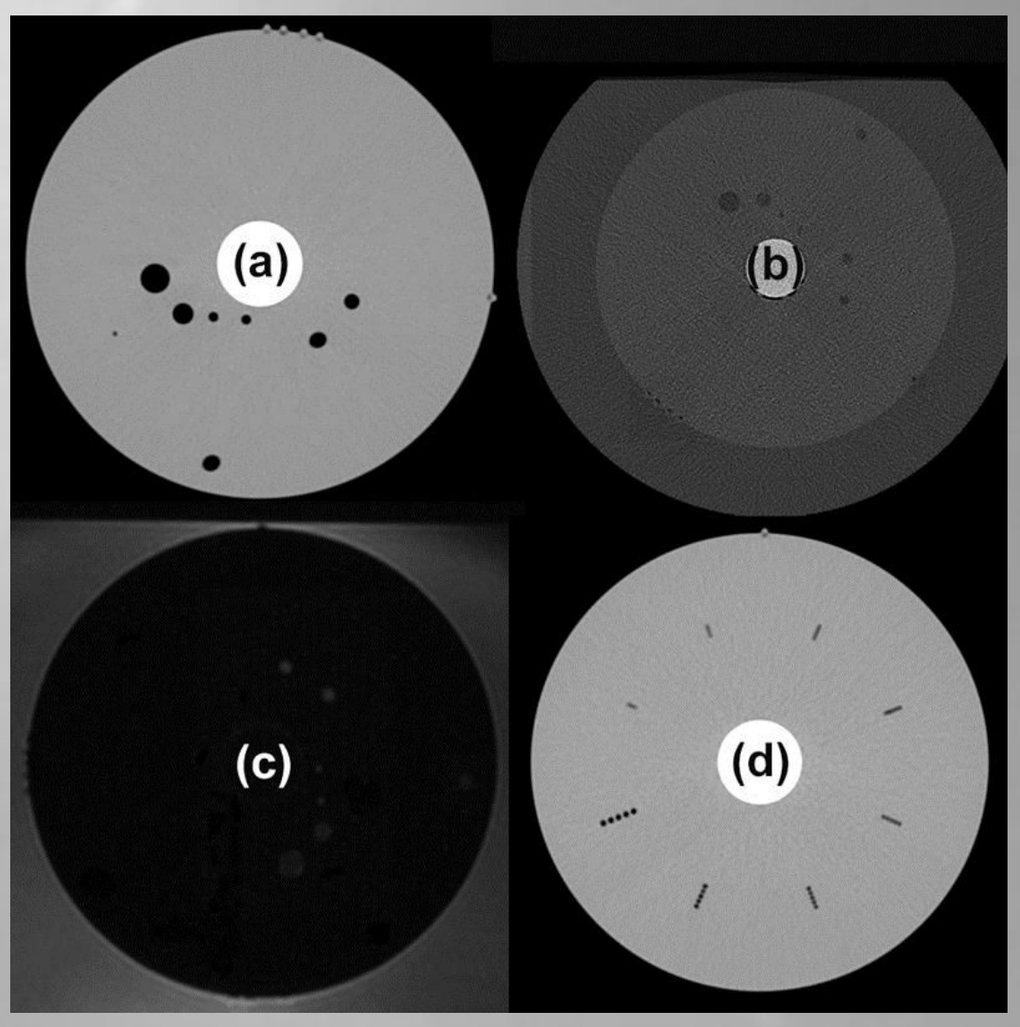

Figure 2. (a) CT of disc 1 with the disc in air (Lightspeed VCT), (b) CT of disc 1 with the disc in water (Aquilion 64), (c) MRI of disc 1 with the disc in water, (d) CT of the spatial resolution disc in air (Lightspeed VCT).

Results

(a) Images of the discs were reconstructed successfully with all scanners and modalities (Figure 2). All features in the disc were visible in the high contrast CT (Figure 2(a)).

(b) In the low contrast CT the smallest hole was at best borderline for identification (Figure 2(b)). All other features could be located. The orthogonal orientation marker confirmed that the disc had been flipped as well as rotated from the scan position in Figure 2(a).

(c) Similar results for low contrast feature identification were found from the MRI of the discs in water (Figure 2(c)).

(d) A high contrast CT image of the spatial resolution disc in air is included in Figure 2(d).

Conclusions

High contrast (test phantom in air) and low contrast (test phantom in water) feature images have been produced successfully demonstrating the suitability of the phantom in both CT and MRI, its extremes of performance and feature detectability when reporting. The test phantom itself is simple, cost-effective, but most importantly was designed to overcome the learning effects during reporting which are a problem in phantoms with fixed feature geometry and patterns that can be learnt and anticipated.

Table 1. Imaging tests (a), (b), and (c).

	Imaging test		
	(a)	**(b)**	**(c)**
Modality	MDCT	MDCT	MRI
Scanner	64-slice LightSpeed VCT	Aquilion 64	1.5T Genesis Signa
Manufacturer	GE Medical Systems	Toshiba Medical Systems	GE Medical Systems
Mode	Helical + AEC	Helical + AEC	Breath-Hold T2-Weighted
	(Tube current modulation)	(Sure Exposure)	(TORSO PA coil)
Details	rotation time 1.8 s	rotation time 0.8 s	fat suppression (Fat SAT)
	slice thickness 0.625 mm	slice thickness 0.5 mm	TR 2000 ms
	pitch 0.984	pitch 0.641	TE 93 ms
	standard kV 120	standard kV 120	echo time 23 ms
Phantom contrast	High – in air	Low – in water	Low – in water