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A medical device grade T2 phantom to quality control inflammation imaging by CMR

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Introduction: T2 mapping can detect areas of myocardial edema, however, with the absence of a quality control (QC) system, single-center findings are not generalizable, longitudinal studies cannot robustly track changes in T2, and our ability to detect global inflammation is undermined.

Having already developed the first global CMR QC system for T1 mapping – the CE-mark/FDA-approved T1MES phantom, we now utilize the know-how, tube recipes, analysis infrastructure, and industry support to design and build for the CMR community the first dedicated T2 mapping phantom to medical device standards.

Methods: A design collaboration consisting of a specialist MRI small-medium enterprise, clinicians, physicists and national metrology institutes was formed. We carried out a literature search to select the optimum phantom materials and the target T1/T2 combinations for the internal tubes to mimic physiologically relevant native T1/T2 values in myocardium across the spectrum of health and disease.

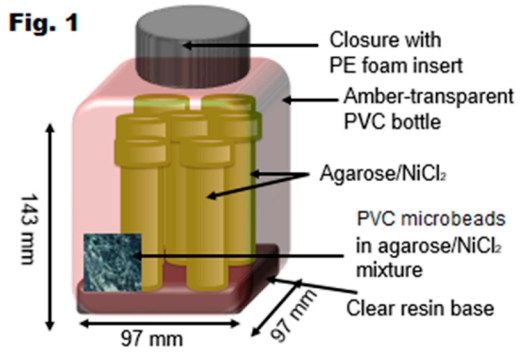
Results: The T2 phantom prototype we are proposing (Fig.1) is field-strength specific and will contain 7 differently doped agarose tubes mixed with Nickel Chloride (Figs.2&3). Table 1 summarises the physiological scope per tube. Phantom design sought to minimise B0 and B1 inhomogeneities known to impact CMR T2 mapping. Prototype development is currently underway and we plan to present experimental data examining the phantom's stability in terms of its robustness to B0/B1 inhomogeneity, gibbs ringing, intra-scanner, inter-scanner, and inter-sequence reproducibility.

Conclusion: The T2 mapping CMR phantom will support CMR research in inflammation by enabling quality control of T2 mapping sequences for multicenter clinical research.

List of target T1|T2 tube values

Physiological scope	Tube target at 1.5T			Tube target at 3T		
	sT2 (ms)	sT1 (ms)	mT1 (ms)	sT2 (ms)	sT1 (ms)	mT1 (ms)
“Short” T1 | “Normal” T2 (A)	~45	~800	~771	~45	~950	~897
“Normal” T1 | “Normal” T2 (B)	~45	~1050	~998	~45	~1250	~1175
“Normal” T1 | “Short” T2 (C)	~30	~1050	~997	~30	~1250	~1174
“Long” T1 | “vLong” T2 (D)	~75	~1300	~1247	~75	~1550	~1423
“Long” T1 | “Normal” T2 (E)	~45	~1300	~1245	~45	~1550	~1419
“Normal” T1 | “Long” T2 (F)	~60	~1050	~999	~60	~1250	~1177
“Long” T1 | “Long” T2 (G)	~60	~1300	~1246	~60	~1550	~1421

sT2 = T2 by slow SE, sT1 = T1 by slow IR, mT1 = T1 by MOLLI 5(3)3.
Abstract 27 Figure. T2 phantom design and tube values



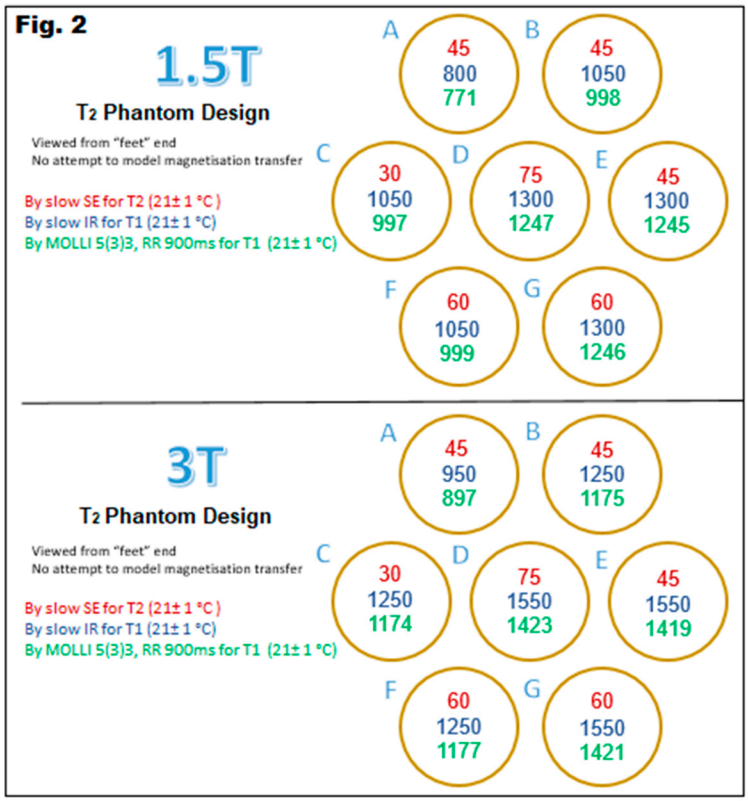


Fig. 3 T_2 Phantom Tube T_1/T_2 Values at 1.5T

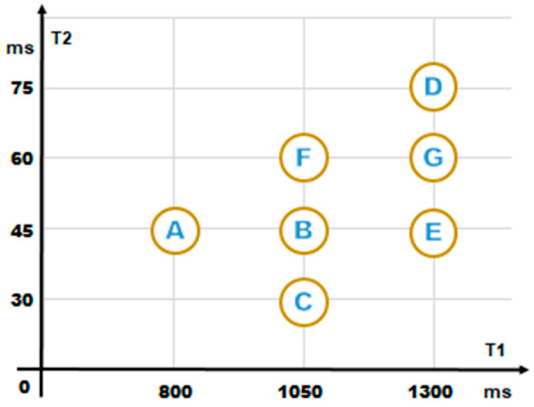


Fig. 1 Internal and external phantom structure, looking at the front. PE = Polyethylene; PVC = Poly Vinyl Chloride; $NiCl_2$ = Nickel Chloride.
Fig. 2 T_1 and T_2 values in T_2 mapping CMR phantom mimic the myocardium in health and disease at 1.5T (top panel) and 3T (bottom panel). Slow SE scan reference data for T_2 displayed in red, slow IR in blue, and MOLLI 5(3)3, RR 900ms for T_1 in green represent the mean value per tube. SE = Spin Echo, IR = inversion recovery, RR = inter-beat interval. All T_1 | T_2 values are stated in ms.
Fig. 3 T_1 | T_2 points in a scatter chart. Horizontal arrow values indicate tubes in 1.5T. All values are stated in ms.