RSNA QIBA Meeting – May 25-26, 2010

RSNA QIBA DCE-MRI Technical Committee MR Phantom Development / Data Efforts

Ed Jackson
Co-Chair – MRI Quantitative Committee

May 25, 2010

Quantitative Imaging Biomarkers Alliance RSNA

RSNA QIBA DCE-MRI Phantom v1 Studies

- MR phantom based on the Imaging Response Assessment Team (IRAT) DCE-MRI phantom
- Acquisition and phantom designed to mimic typical Phase I / II applications to liver using phased array receive coils
- Phantoms distributed to multiple sites to obtain multicenter (N=5), multivendor (N=3) data

"Cuboid"

Modified ADNI MagPhan

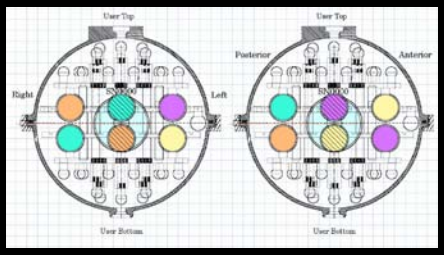
http://qibawiki.rsna.org/index.php?title=DCE-MRI

2

Phantom purchase funded by NCI Contract 27XS112

RSNA QIBA DCE-MRI Phantom v1

- Modified version of the ADNI MagPhan, as previously modified by IRAT MR Committee
- 1-cm fiducial spheres for spatial accuracy assessment unchanged
- Eight 3-cm contrast response spheres (same as IRAT modified version)
- T1 modifier: $CuSO_4$
- Flood fill solution of phantom and cuboid changed to 30 mM NaCl



Two matched phantoms were manufactured by The Phantom Laboratory (Salem, NY)

(Phantom purchase funded by NCI Contract 27XS112)

http://qibawiki.rsna.org/index.php?title=DCE-MRI

3

RSNA QIBA DCE-MRI Phantom v1 Studies

- Phantom measurements (overview):
  - Phased array acquisition
  - Body coil acquisition
  - SNR acquisition
  - Variable flip angle T1 measurement acquisition
  - DCE acquisition

  } Ratio map correction for RF coil sensitivity characteristics

- Each of the above acquisitions repeated with phantom rotated by 90, 180, 270, and 360°
- All acquisitions repeated one week later
- Sites / vendors

– MDACC	GE (new)	Site 1 / Vendor A
– UPenn	Siemens (2)	Site 2 / Vendor B
– Univ Chicago	Philips	Site 3 / Vendor C
– Duke Univ	Philips	Site 4 / Vendor C
– Univ CA Davis	GE (older)	Site 5 / Vendor A

4

RSNA QIBA DCE-MRI Phantom v1 Studies

Rotation A (also repeated 1 week later)	**Time (min)**
Scout & Setup	5
Ratio images - body coil receive	2
Ratio images - phased array coil receive	2
SNR images - phased array coil receive (8 separate acquisitions with 1 excitation each)	2
R1 VFA acquisition	8
DCE (40 phases)	6
	25
Rotation B	
Scout & Setup	5
Ratio images - body coil receive	2
Ratio images - array coil receive	2
SNR images - phased array coil receive (8 separate acquisitions with 1 excitation each)	2
R1 VFA acquisition	8
DCE (6 phases)	1
	20

- Rotations C and D same as Rotation B
- Rotation A' same as Rotation A

5

RSNA QIBA DCE-MRI Phantom v1 Studies

Generic Ratio Protocol				
B0:	1.5T	1.5T	3.0T	3.0T
Grad Subsystem:	CRM	BRM	TRM	TRM
Coil:	Torso PA / Body Coil	Torso PA / Body Coil	Body Array / Body Coil	Body Array / Body Coil
Slice orientation:	Oblique Coronal	Oblique Coronal	Oblique Coronal	Oblique Coronal
Sequence:	3D FSPGR	3D FSPGR	3D FSPGR	3D FSPGR
Imaging Options:	EDR, MPH, ZIP2, ZIP512	EDR, MPH, ZIP2, ZIP512	EDR, MPH, ZIP2, ZIP512	EDR, MPH, ZIP2, ZIP512
User CVs:	Turbo=2 / Slice res=100%	Turbo=2 / Slice res=100%	Turbo=2 / Slice res=100%	Turbo=2 / Slice res=100%
Grad Mode:	N/A	N/A	Whole	Zoom
TE (ms):	0.8	0.9	1.2	1.0
TR (ms):	3.8	4.1	4.7	4.4
Flip Angle (deg):	15	15	15	15
Bandwidth:	+/- 32 kHz	+/- 32 kHz	+/- 32 kHz	+/- 32 kHz
NEX:	8	8	8	8
FOV (cm):	42	42	42	42
Phase FOV:	0.8	0.8	0.8	0.8
Slice Thickness (mm):	8	8	8	8
# locs per slab:	16	16	16	16
Acquisition matrix:	256 x 160	256 x 160	256 x 160	256 x 160
Freq Direction:	S/I	S/I	S/I	S/I
Acq Time (min):	1:04	1:06	1:06	1:06

- Ratio data acquired once with body coil and repeated with phased array coil
- Same two sets of data acquired at each rotation
- Phased array acquisition repeated at each rotation for SNR, but 8 separate acqs

6

RSNA QIBA DCE-MRI Phantom v1 Studies

Generic T1 Mapping Protocol				
B0:	1.5T			
Grad Subsystem:	CRM			
Coil:	Torso PA / Body Coil			
Slice orientation:	Oblique Coronal			
Sequence:	3D FSPGR			
Imaging Options:	EDR, MPH, ZIP2, ZIP512			
User CVs:	**Turbo=0** / Slice res=100%	If Turbo=1 or 2 is used, the TR varies with flip angle. Even with Turbo=0, TR may vary for >30 deg flip angle.		
Grad Mode:	N/A			
TE (ms):	1.0			
TR (ms):	5.2			
Flip Angle (deg):	2, 5, 10, 15, 20, 25, 30			
Bandwidth:	+/- 32 kHz			
NEX:	4			
FOV (cm):	42			
Phase FOV:	0.8			
Slice Thickness (mm):	8			
# locs per slab:	16			
Acquisition matrix:	256 x 160			
Freq Direction:	S/I			
Acq Time (min):	43 sec / flip angle			

- VFA T1 data acquired at each rotation

7

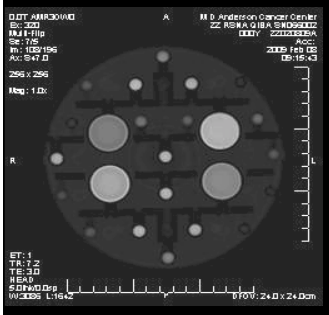
RSNA QIBA DCE-MRI Phantom v1 Studies

Generic DCE Scan				
B0:	1.5T	1.5T	3.0T	3.0T
Grad Subsystem:	CRM	BRM	TRM	TRM
Coil:	Torso PA	Torso PA	Body Array	Body Array
Slice orientation:	Oblique Coronal	Oblique Coronal	Oblique Coronal	Oblique Coronal
Sequence:	3D FSPGR	3D FSPGR	3D FSPGR	3D FSPGR
Imaging Options:	EDR, MPH, ZIP2, ZIP512	EDR, MPH, ZIP2, ZIP512	EDR, MPH, ZIP2, ZIP512	EDR, MPH, ZIP2, ZIP512
User CVs:	Turbo=2 / Slice res=100%	Turbo=2 / Slice res=100%	Turbo=2 / Slice res=100%	Turbo=2 / Slice res=100%
Grad Mode:	N/A	N/A	Whole	Zoom
TE (ms):	0.9	0.9	1.2	1.0
TR (ms):	4.1	4.1	4.7	4.4
Flip Angle (deg):	30	30	30	30
Bandwidth:	+/- 32 kHz	+/- 32 kHz	+/- 32 kHz	+/- 32 kHz
NEX:	1	1	1	1
FOV (cm):	42	42	42	42
Phase FOV:	0.8	0.8	0.8	0.8
Slice Thickness (mm):	8	8	8	8
# locs per slab:	16	16	16	16
Acquisition matrix:	256 x 160	256 x 160	256 x 160	256 x 160
Freq Direction:	S/I	S/I	S/I	S/I
Scan time/volume:	8.5 sec	8.6 sec	9.9 sec	9.4 sec
Scan time / 40 volumes:	5:40	5:44 min	6:37 min	6:15 min

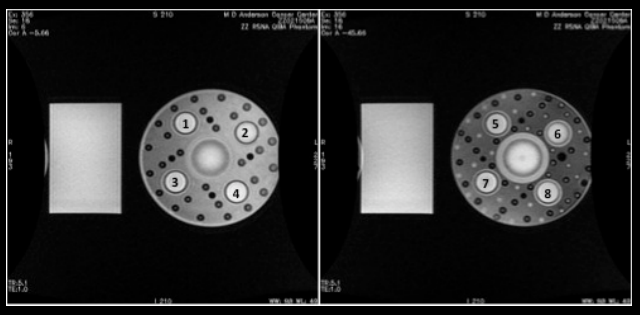
- DCE data acquired at each rotation
- 5:40 min acquisitions at Rotation A and A'; 51 sec acqs at Rotations B-C

8

RSNA QIBA DCE-MRI Phantom v1 Studies



Axial

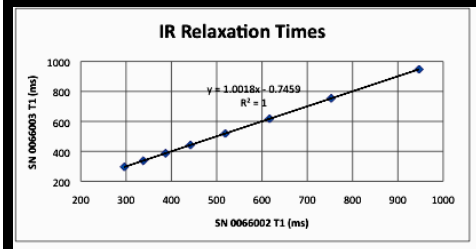


Coronal

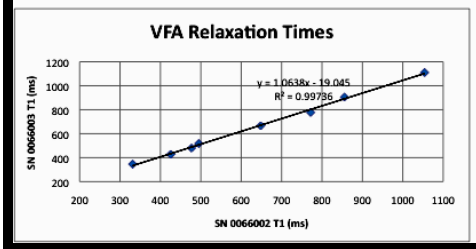
Typical images showing the eight T1 contrast spheres

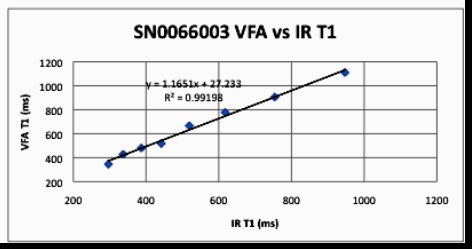
9

RSNA QIBA DCE-MRI Phantom v1 Studies



Initial phantom inter-comparison tests and IR-based T_1 measures (MDACC only)





10

RSNA QIBA DCE-MRI Phantom v1 Studies

- Data Analysis: The raw data analysis was carried out using software developed by VirtualScopics, Inc. (Ed Ashton, PhD)
- From the DCE-MRI acquisition data, signal intensity, SNR, and CNR measures were computed from each of the eight contrast spheres.
- T_1 measures were computed from the VFA data from each sphere. These measures were obtained both before and after correction of the phased array coil data for spatial variations in coil sensitivity.
- Coil sensitivity corrections were carried out as follows:
  1. Import the body coil and phased array ratio images
  2. Normalize the range of the two images
  3. Calculate signal intensity ratios (body coil:phased array) for each pixel
  4. Apply 21x21 pixel kernel median filter
  5. Multiply each pixel in the source image by the ratio map pixel data

11

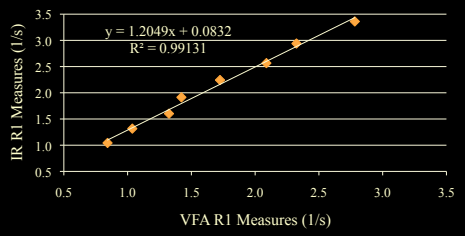
RSNA QIBA DCE-MRI Phantom v1 Studies

- Analysis of the signal characteristics in the DCE scans was accomplished by placing a uniform spherical 2-cm diameter region of interest (ROI) in the center of each phantom compartment.
- Mean and median pixel values within each ROI were calculated, along with SNR and CNR values.
  - Noise in each compartment was defined as the standard deviation of the differences at each pixel between one phase and the next divided by √2.
  - Signal was defined as the mean signal value within each ROI.
  - Contrast was defined as the absolute difference between the mean signal in an ROI and that of the central 6-cm sphere.
- The raw data thus obtained were provided to the QIBA DCE-MRI Technical Committee for further analysis (Ed Jackson, PhD).

12

RSNA QIBA – Multiple Vendors / Three Time Points

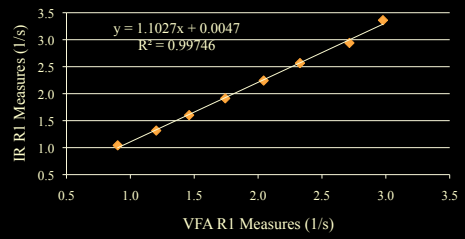
VFA R1 vs IR R1 – Site 2 / Vendor B



Variable flip angle relaxation rates vs. IR (gold standard) values (Site 2 / Vendor B)

IR measures acquired on Vendor A at Site 1

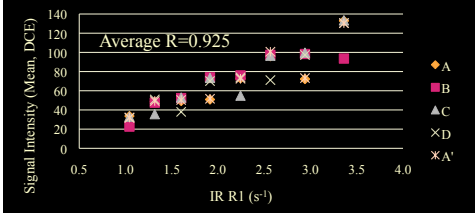
VFA R1 vs IR R1 – Site 1 / Vendor A



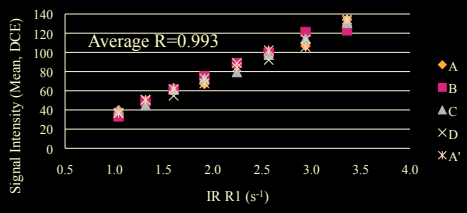
Variable flip angle relaxation rates vs. IR (gold standard) values (Site 1 / Vendor A)

RSNA QIBA – Multiple Vendors / Three Time Points

Uncorrected – Site 2 / Vendor B

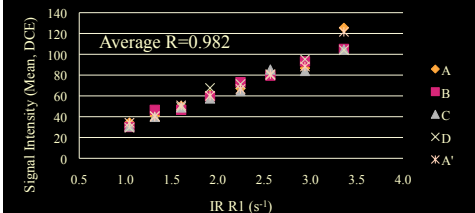


Corrected – Site 2 / Vendor B



Comparison of Signal Intensity Change vs Relaxation Rate

Uncorrected – Site 1 / Vendor A



Corrected – Site 1 / Vendor A

RSNA QIBA – Site 1 / Vendor A

Week 0

Correlation Coefficient - Uncorrected					Correlation Coefficient - Corrected				
A	B	C	D	A'	A	B	C	D	A'
0.9714	0.9937	0.9888	0.9919	0.9796	0.9918	0.9936	0.9970	0.9935	0.9943
Mean:	0.9851				Mean:	0.9940			
Slope - Uncorrected					Slope - Corrected				
A	B	C	D	A'	A	B	C	D	A'
35.4555	31.5497	30.9754	32.0993	34.7666	38.5062	37.3991	38.9269	38.3421	38.3138
Mean:	32.97		CV%:	6.10	Mean:	38.30		CV%:	1.46
Intercept - Uncorrected					Intercept - Corrected				
A	B	C	D	A'	A	B	C	D	A'
-6.6755	-0.2397	-1.3036	-0.9638	-5.9848	-1.0992	-0.1563	-4.6193	-2.3849	-1.1261
Mean:	-3.03		CV%:	-100.34	Mean:	-1.88		CV%:	-91.91

Comparison of Signal Intensity Change vs. Relaxation Rate

Week 1

Correlation Coefficient - Uncorrected					Correlation Coefficient - Corrected				
A	B	C	D	A'	A	B	C	D	A'
0.9692	0.9922	0.9810	0.9874	0.9784	0.9929	0.9939	0.9966	0.9931	0.9935
Mean:	**0.9816**				Mean:	0.9940			
Slope - Uncorrected					Slope - Corrected				
A	B	C	D	A'	A	B	C	D	A'
35.5064	30.3643	31.7126	33.8272	34.2843	38.5615	31.8471	39.6217	40.4038	37.6590
Mean:	33.14		CV%:	6.24	Mean:	37.62		CV%:	9.01
Intercept - Uncorrected					Intercept - Corrected				
A	B	C	D	A'	A	B	C	D	A'
-6.8297	1.4830	-0.2094	-4.1020	-6.1966	0.0705	0.0760	-2.9446	-5.4970	-0.6708
Mean:	-3.17		CV%:	-115.70	Mean:	-1.79		CV%:	-134.51

RSNA QIBA – Site 2 / Vendor B

Week 0

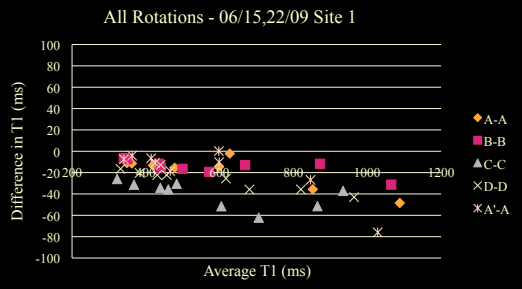
Correlation Coefficient - Uncorrected					Correlation Coefficient - Corrected				
A	B	C	D	A'	A	B	C	D	A'
0.8995	0.9272	0.9518	0.9435	0.9015	0.9925	0.9898	0.9962	0.9942	0.9917
Mean:	0.9247				Mean:	0.9929			
Slope - Uncorrected					Slope - Corrected				
A	B	C	D	A'	A	B	C	D	A'
35.8478	31.4245	41.5087	37.7724	35.8782	39.3105	40.2707	39.9166	40.5411	39.8852
Mean:	36.49		CV%:	10.00	Mean:	39.98		CV%:	1.16
Intercept - Uncorrected					Intercept - Corrected				
A	B	C	D	A'	A	B	C	D	A'
-6.5579	3.5212	-15.6972	-9.7263	-6.1318	-2.5304	-4.0917	-4.6574	-5.8299	-4.2140
Mean:	-6.92		CV%:	-100.84	Mean:	-4.26		CV%:	-27.85

Comparison of Signal Intensity Change vs. Relaxation Rate

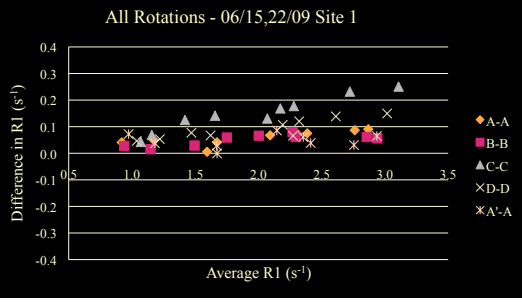
Week 1

Correlation Coefficient - Uncorrected					Correlation Coefficient - Corrected				
A	B	C	D	A'	A	B	C	D	A'
0.8796	0.9040	0.9476	0.9289	0.8870	0.9916	0.9909	0.9960	0.9945	0.9934
Mean:	0.9094				Mean:	0.9933			
Slope - Uncorrected					Slope - Corrected				
A	B	C	D	A'	A	B	C	D	A'
31.9288	29.9869	38.5522	37.8572	32.0270	36.5484	40.1997	38.3974	40.3200	37.1238
Mean:	34.07		CV%:	11.35	Mean:	38.52		CV%:	4.48
Intercept - Uncorrected					Intercept - Corrected				
A	B	C	D	A'	A	B	C	D	A'
-1.7959	2.8835	-14.8472	-13.2291	-2.4637	-2.9824	-4.9947	-6.1627	-7.2638	-2.5046
Mean:	-5.89		CV%:	-131.38	Mean:	-4.78		CV%:	-42.52

RSNA QIBA – Multiple Vendors / Three Time Points



Difference in T1 from each contrast sphere, week 1 minus week 0.



Difference in R1 from each contrast sphere, week 1 minus week 0.

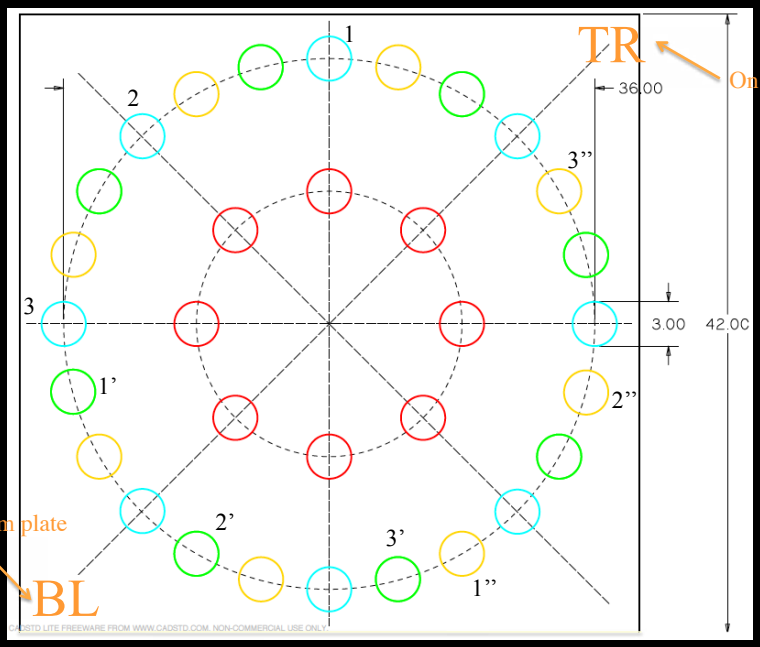
RSNA QIBA – Multiple Vendors / Three Time Points

- Status:

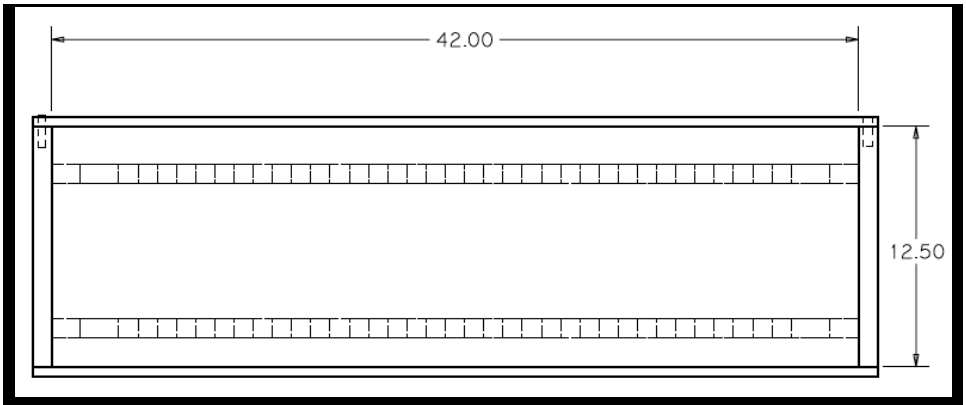
– MDACC	GE (new)	Site 1 / Vendor
– UPenn	Siemens (2)	Site 2 / Vendor B
– Univ Chicago	Philips	Site 3 / Vendor C
– Duke Univ	Philips	Site 4 / Vendor C
– Univ CA Davis	GE (older)	Site 5 / Vendor A

- Phantoms are currently "in residence" at:
  - Univ Chicago
  - Duke Univ

18



QIBA DCE-MRI Prototype Phantom – v2 (Concept from Evelhoch)

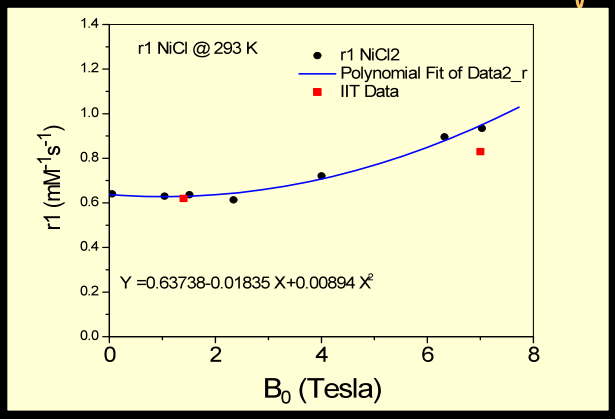


Properties – 50 ml

material	polypropylene
sterility	sterile
mfr. no.	Corning, 430897
L	114.9 mm
O.D.	29.1 mm
cap diam.	35.2 mm
capacity	50 ml

QIBA DCE-MRI Prototype Phantom – v2

RSNA QIBA DCE-MRI Phantom v2



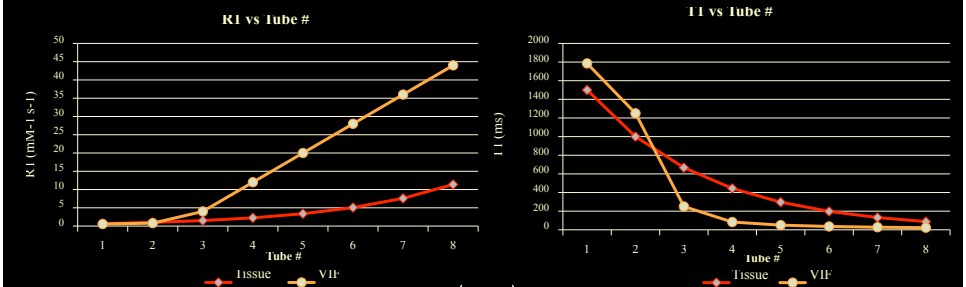
$NiCl_2$ $r_1 \approx 0.62\ mM^{-1}\ s^{-1}$ (0.1 ~ 3.0T)

Graph from Steve Russek, NIST Boulder
see also Fig 2a in Rooney *et al*. Magn Reson Med 57:308, 2007 and Kraft *et al*., Magn Reson Med 5:555, 1987

21

RSNA QIBA DCE-MRI Phantom v2

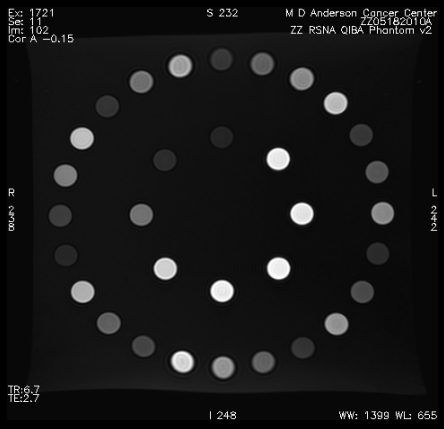
Tissue						VIF					
T1 (ms)	R1 (s-1)	Delta R1	[NiCl2] mM	NiCl2 mg/l	NiCl2 mg/40ml	R1 (s-1)	T1 (ms)	Delta R1	[NiCl2] mM	NiCl2 mg/l	NiCl2 mg/40ml
1500.0	0.67	0.00	1.075	139.35	5.57	0.56	1785.7	0.00	0.903	117.06	4.68
1000.0	1.00	0.33	1.613	209.03	8.36	0.80	1250.0	0.24	1.290	167.23	6.69
666.7	1.50	0.83	2.419	313.55	12.54	4.00	250.0	3.44	6.452	836.13	33.45
444.4	2.25	1.58	3.629	470.32	18.81	12.00	83.3	11.44	19.355	2508.39	100.34
296.3	3.38	2.71	5.444	705.48	28.22	20.00	50.0	19.44	32.258	4180.65	167.23
197.5	5.06	4.40	8.165	1058.23	42.33	28.00	35.7	27.44	45.161	5852.90	234.12
131.7	7.59	6.93	12.248	1587.34	63.49	36.00	27.8	35.44	58.065	7525.16	301.01
87.8	11.39	10.72	18.372	2381.01	95.24	44.00	22.7	43.44	70.968	9197.42	367.90
	Series 3		0.62 mM-1 s-1		274.57	mg NiCl2 per group of 8 vials					1215.40
					823.72	mg NicCl2 for 3 groups of vials					



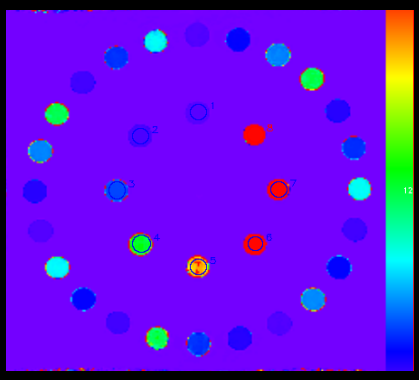
22

QIBA DCE-MRI Prototype Phantom – v2

RSNA QIBA DCE-MRI Phantom v2



VFA Data (α=20°)



R1 Map (0 – 25 s^{-1})

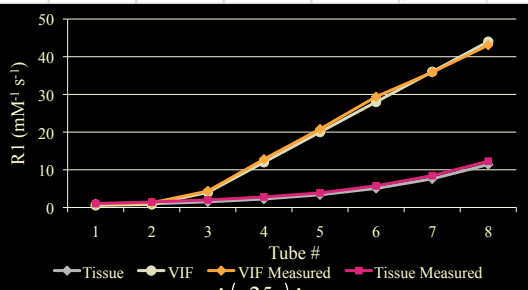
FSE-IR Data - MDACC

24

RSNA QIBA DCE-MRI Phantom v2

Measured R1 (FSE-IR) - Acq Date: 05/18/2010						
VIF	Tissue1	Tissue2	Tissue3	Ave Tissue	Stdev	%CV
0.97	1.06	1.06	1.07	1.06	0.006	0.54
1.24	1.44	1.44	1.45	1.44	0.006	0.40
4.36	2.00	2.01	2.00	2.00	0.006	0.29
12.81	2.79	2.80	2.78	2.79	0.010	0.36
20.81	3.94	3.81	3.86	3.87	0.066	1.69
29.39	5.86	5.66	5.72	5.75	0.103	1.79
35.87	8.51	8.48	8.34	8.44	0.091	1.07
43.08	12.48	12.09	12.23	12.27	0.198	1.61
T1 fill:	2921.68	ms	R1 fill:	0.34	/sec	

FSE-IR Data

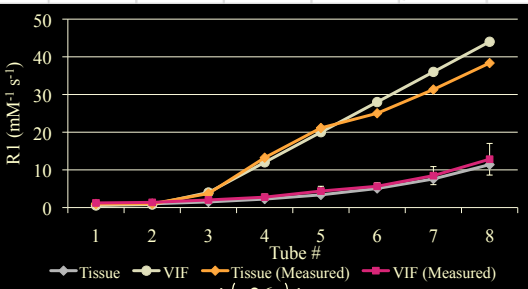


25

RSNA QIBA DCE-MRI Phantom v2

Measured R1 (VFA) - Acq Date: 05/23/2010						
VIF	Tissue1	Tissue2	Tissue3	Ave Tissue	Stdev	%CV
0.97	1.73	0.74	1.22	1.23	0.495	40.25
1.03	1.24	1.50	1.40	1.38	0.131	9.50
3.72	1.54	2.69	1.82	2.02	0.600	29.74
13.24	2.27	2.28	3.73	2.76	0.840	30.44
21.13	5.82	3.43	3.88	4.38	1.270	29.02
25.02	4.71	5.69	6.56	5.65	0.926	16.37
31.33	7.43	11.22	6.78	8.48	2.398	28.29
38.35	10.43	10.39	17.67	12.83	4.192	32.67
T1 fill:	3060.76	ms	R1 fill:	0.33	/sec	

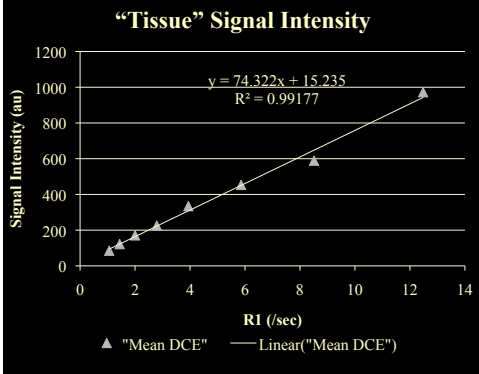
VFA Data

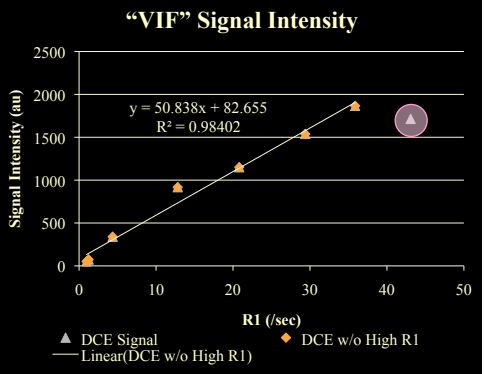


26

RSNA QIBA DCE-MRI Phantom v2

DCE Signal Signal Intensity Data

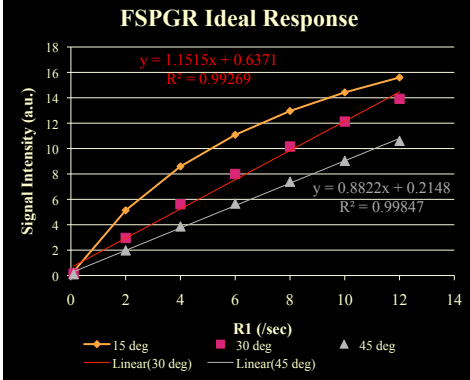


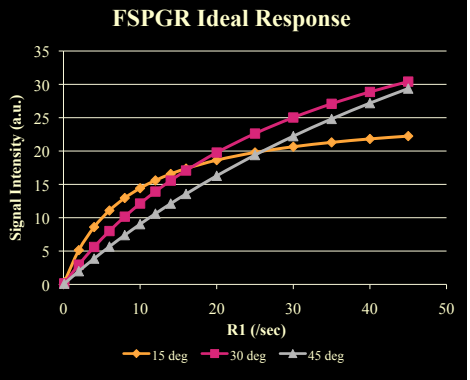


27

RSNA QIBA DCE-MRI Phantom v2

Theoretical Response (ignoring R2*)



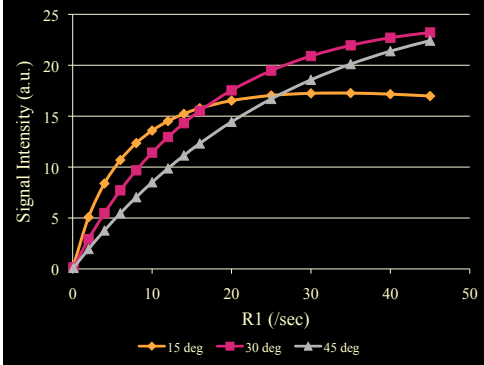


28

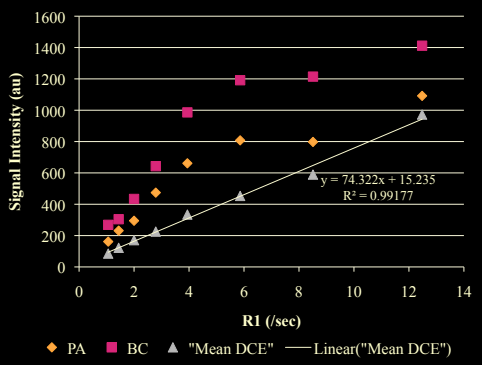
RSNA QIBA DCE-MRI Phantom v2

Theoretical Response (with R2*=5•R1)

FSPGR Ideal Response, with R2*



Signal Intensity vs. R1



PA and BC ratio data acquired with α=15°

29

RSNA QIBA DCE-MRI Phantom v2

- R1 measures from FSE-IR data agree extremely well with design targets for both the "VIF" and "tissue" compartments.
- R1 measures from VFA data do <u>not</u> agree, even if FOV is extended to 48 cm and matrix increased to 256x256, on a CRM gradient subsystem GE 1.5T scanner (shorter, 55-cm diameter gradient coil).
- Tissue R1 measures from VFA data on a BRM gradient subsystem GE 1.5T scanner, with 48 cm FOV agree well when averaged over all 3 "pseudo rotations". (Same matrix as original protocol, but with ±62.5 kHz bandwidth.) VIF R1 measures agree up to ~25 s^{-1}.
- One other issue: Total mass of $NiCl_2$ is 2.04 g.

30

RSNA QIBA DCE-MRI Phantom v2

B0:	1.5T	
Grad Subsystem:	CRM	BRM
Coil:	Torso PA	
Slice orientation:	Oblique Coronal	
Sequence:	3D FSPGR	
Imaging Options:	EDR, MPH, ZIP2, ZIP512	
User CVs:	Turbo=2 / Slice res=100%	
Grad Mode:	N/A	
TE (ms):	0.9	1.16 ms
TR (ms):	4.1	4.21 ms
Flip Angle (deg):	30	
Bandwidth:	+/- 32 kHz	±62.5 kHz
NEX:	1	
FOV (cm):	42	48 cm
Phase FOV:	0.8	0.85
Slice Thickness (mm):	8	
# locs per slab:	16	
Acquisition matrix:	256 x 160	
Freq Direction:	S/I	
Scan time/volume:	8.5 sec	9.45 sec
Scan time / 40 volumes:	5:40	6:18

Acquisition Parameters Modified for BRM Gradient Scanner w/48-cm FOV

31

RSNA QIBA DCE-MRI Phantom v2

- To keep the original acquisition protocol parameters, particularly FOV, the diameter of the "tissue" compartments will likely need to be decreased, which will require either:
  - reducing the number of "pseudo rotations" from 3 to 2, or
  - reducing the number of samples per rotation from 8 to 7
- Otherwise, the FOV will need to be increased and systems with smaller diameter bores (55 cm) and shorter gradient coils (e.g., GE CRM) will be problematic.

- One other issue relevant to shipping the phantom: The total mass of $NiCl_2$ is 2.04 g.

32

Other Quantitative MR Initiatives

Quantitative MR Imaging Initiatives

- NCI: RIDER and Academic Center Contracts
- NCI: Imaging Response Assessment Team (IRAT) / MR Committee
- RSNA: Quantitative Imaging Biomarker Alliance MR Committee
- ISMRM: *Ad Hoc* Committee on Standards for Quantitative MR
- AAPM: Quantitative Imaging Initiative / Working Group for Standards for Quantitative MR Measures
- NCI: Quantitative Imaging Initiative (QIN)

33

NCI RIDER

NCI Cancer Imaging Program **RIDER**

– Reference Image Database to Evaluate Response*

Collaborative project for development and implementation of a caBIG public resource

Data and meta analyses made publically available through NBIA (phantom and anonymized human subject data, including DCE-MRI and diffusion MRI)

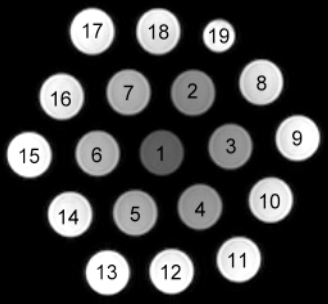
Series of manuscripts in *Translational Oncology* in Dec 2009

https://wiki.nci.nih.gov/display/CIP/RIDER

34

NCI RIDER DCE-MRI Phantom Data

Gel-filled compartments with varying T1 relaxation times
Eurospin TO5 – DiagnosticSonar, Ltd.

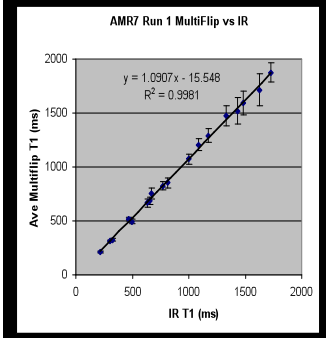


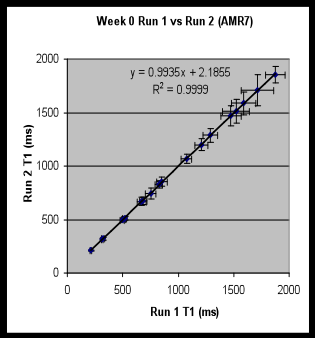
Compartment #	T1 IR (ms)
1	215.25
2	320.18
3	303.80
4	493.36
5	484.81
6	471.17
7	656.59
8	634.46
9	809.73
10	768.12
11	1001.02
12	1728.28
13	1086.39
14	1173.85
15	1331.32
16	1479.87
17	1432.01
18	1624.85
19	669.70

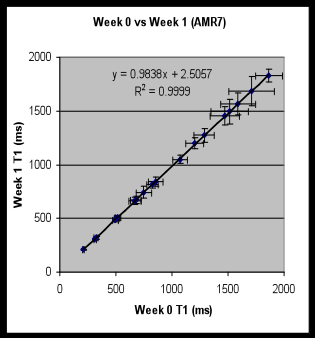
35

Funded by NCI Contract N01-CO-12400 and 27XS112

RIDER– Single Vendor / Multiple Time Points







Run 1 = baseline

Run 2 = 2 hrs post baseline

Week 1 = 1 week post baseline

Bosca & Jackson, AAPM 2009; Jackson *et al*., *Trans Oncol*, Dec 2009

36

Funded by NCI Contract N01-CO-12400 and 27XS112

ISMRM Ad Hoc Committee

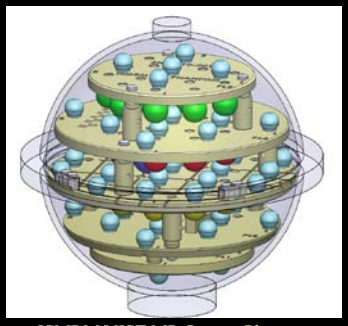
ISMRM: *Ad Hoc* Committee on Standards for Quantitative MR (SQMR)

- Membership includes MR physicists, technologists, radiologists, NIST staff, NCI/CIP staff, vendors, and pharma. Expertise in research trials using quantitative MR.
- Current status:
  - White paper on quantitative MR
  - Design specifications & construction of an "open source" MR system phantom (collaboration with and funding by NIST)
  - Initial multicenter / multivendor phantom pilot studies to begin in May 2010.

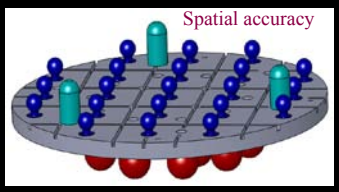
http://wiki.ismrm.org/twiki/bin/view/QuantitativeMR/

37

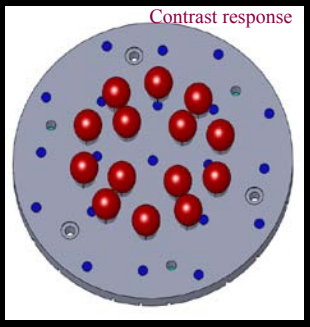
ISMRM SQMR System Phantom

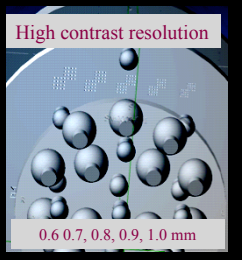


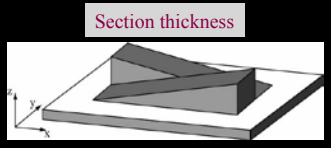
ISMRM/NIST MR System Phantom



All materials characterized by NIST







ISMRM SQMR System Phantom