Final Report
March 13, 2013

Project: DCE-MRI Phantom Fabrication, Data Acquisition and Analysis, and Data Distribution
(HHSN268201000050C-Project #6a)

PI: Edward F. Jackson, PhD

Goal 1: Obtaining four copies of a commercialized version of the prototype QIBA DCE-MRI Phantom design.

Four initial copies of the QIBA DCE-MRI Phantom were purchased from The Phantom Laboratories. The phantoms were provided, unfilled, to the PI. Filling solutions were prepared at MD Anderson Cancer Center and the four phantoms prepared using the same stock $NiCl_2$ solutions. (See attached drawings and target T_1 information.) The phantoms were scanned at 1.5T using a variable inversion time relaxometry sequence and T_1 values from each sphere in each copy of the phantom were obtained and compared to cross-validate the four copies of the phantom. In addition, variable flip angle (VFA) T_1 relaxometry data, DCE-MRI data, and ratio map correction scans (body coil and phased array) data were acquired per the DCE-MRI Technical Committee phantom scanning protocol. Finally, variable repetition time (VTR) T_1 relaxometry data were also acquired. All results from the analyses of these data were reviewed with the DCE-MRI Technical Committee during regularly scheduled teleconferences.

As a result of cost savings in the phantom manufacturing relative to the originally quoted prices, four additional copies of the QIBA DCE-MRI Phantom were purchased at no increase in subcontract funding. These four additional copies have been received by the PI.

At this time, two copies of the QIBA DCE-MRI Phantom have been placed into use in the site qualification process for the QIBA/ACRIN 6701 test/retest clinical trial (Phase II RSNA/NIBIB DCE-MRI Technical Committee project, PI: Mark Rosen). One additional copy will be placed into use for this purpose in the near future.

Goal 2: Collaboration with VirtualScopics to develop/validate a freely distributed software package to analyze data obtained using the QIBA DCE-MRI Phantom.

The PI has taken the output from the most recent version of the DCE-MRI Phantom Analysis Software (received from VirtualScopics on January 31, 2013; version label 1.0) and revised a previously-developed (at the time of the last interim report) Excel workbook that:

> 1) takes as input each of the validated software output files (the variable flip angle data T_1 calculations and the DCE-MRI acquisition signal intensity and SNR calculations, with and without intensity corrections using the body coil-to-phased array coil ratio map data),
> 2) sorts the data from the VirtualScopics-defined regions-of-interest (ROIs) to the physical phantom samples regions,
> 3) calculates and graphs the relevant parameters for the R_1 calculations (converted from the T_1 data) and also computes Bland-Altman limits of agreement (for the R_1 measurements), and
> 4) calculates and graphs the relevant parameters for the DCE signal intensity *vs*. R_1 analyses and the DCE signal intensity stability analyses.

An example Excel workbook printout using example source results files (*.txt files) generated by the VirtualScopics code (and used as input for the Excel workbook calculations in tabs 1 and 2) is attached. The first two tabs of the workbook provide the analyses discussed above. The next two tabs are the "input spreadsheets" where the user would import the raw output from the VirtualScopics code

(the attached *.txt files). The final tab provides the VirtualScopics ROI to physical phantom sample mapping for one, of several possible in the current software version, ROI labeling schemes.

At this point, the VirtualScopics software and Excel workbook calculations have been confirmed to work correctly with variable flip angle and variable repetition time relaxometry data and DCE-MRI data acquired from both GE and Siemens MR scanners. The variable inversion time relaxometry analysis in the current VirtualScopics software release works correctly for data from samples with relaxation rates less than approximately 12 s^{-1}, *i.e.*, the tissue mimicking samples, but fails for samples with relaxation rates higher than this value, *i.e.*, the vascular input function mimicking samples. This issue, along with the multiple possible ROI numbering / labeling schemes issue noted above, has been identified in a report to be submitted to VirtualScopics.

Note: The phantom data analyzed using the VirtualScopics code have been limited to those obtained on GE and Siemens scanners. It has not yet been possible to fully analyze Philips data using the current VirtualScopics code.   Based on analysis of digital test object data from Tom Chenevert, the image intensity scaling necessary to correctly calculate the results from Philips data does not appear to have been fully incorporated in the VirtualScopics code as of the release received on January 31, 2013.

Goal 3: Phantom distribution to and analysis of data from a minimum of four sites with MR systems from three vendors (GE, Siemens, Philips)

Using the four available QIBA DCE-MRI Phantoms, data have been acquired from:

MD Anderson Cancer Center:
- 1.5T GE HDxt scanner, at multiple time points
- 3.0T GE MR750 scanner, at multiple time points
- (All four copies of the phantom were scanned at 1.5T.)

University of Pennsylvania:
- Siemens 3.0T scanner

Data have not yet been acquired on a Philips MR scanner (to complete the requirement for three different vendors).

Upcoming data will be received by the PI as part of the qualification of sites for the RSNA QIBA / ACRIN 6701 test-retest clinical trial. We expect data to be received soon from three additional sites with Philips, GE, and Siemens scanners. With this data received and processed, the deliverable for this goal will be fully achieved.

Goal 4: Preparation and distribution of source and metadata to a publicly accessible database

A test data set consisting of all source data for one of the GE 1.5T scanner runs has been posted to the Radiology Informatics Committee (RIC) Quantitative Imaging Data Warehouse (QIDW) test server. This test set includes:
- Ratio Data – Body Coil Data
- Ratio Data – Phased Array Coil Data
- Variable Flip Angle T_1 Relaxometry Data
- DCE-MRI Data
- Variable inversion time T_1 Relaxometry Data
- Variable repetition time T_1 Relaxometry Data

The data are contained in the "QIBA DCE-MRI WG" Community and were obtained at 1.5T from a GE HDxt scanner using QIBA DCE-MRI Phantom serial number 09204.

A second test data set, from a 3.0T Siemens scanner at the University of Pennsylvania, has been uploaded, along with test PDF metadata file, in a "sandbox" community named "EFJ Community". This data consists of DCE-MRI data (1690 images), variable flip angle T_1 relaxometry data (182 images), and the two ratio map data sets (body coil and phased array coil, 26 images each).

Such data loads demonstrates the feasibility of using the RIC QIDW test server for the upload of all site qualification data obtained from the QIBA DCE-MRI Phantom site qualification runs in support of the RSNA QIBA / ACRIN 6701 test-retest clinical trial. Therefore, once these data sets are obtained, analyzed, and source data and analysis reports finalized and uploaded to the RIC QIDW test server, the deliverables for this goal will be fully realized.

Summary:

Goal 1 Deliverables:

All deliverables have been met and, in fact, exceeded as eight commercial copies of the QIBA DCE-MRI Phantom are available instead of the original number of four.

Goal 2 Deliverables:

All deliverables under the control of the Project 6A PI have been met, including the development and testing of an Excel workbook to perform all required analyses of the source T_1 relaxometry and DCE-MRI signal intensity data outputs from the VirtualScopics software.

Goal 3 Deliverables:

Full run data sets have been obtained from two of four sites and from two of three MR vendor platforms. The data from the remaining two sites and one MR vendor platform will be obtained as part of the ongoing Phase II RSNA QIBA / ACRIN 6701 test-retest clinical trial site qualification process.

Goal 4 Deliverables:

The ability to successfully upload the source data as well as reports from data analyses has been fully demonstrated using data from 1.5T GE and 3.0T Siemens MR scanners at two sites (MD Anderson Cancer Center and the University of Pennsylvania). Therefore, this goal was achieved and all future site qualification data in support of the RSNA QIBA / ACRIN 6701 test-retest clinical trial site qualification process will be similarly uploaded to this data warehouse.
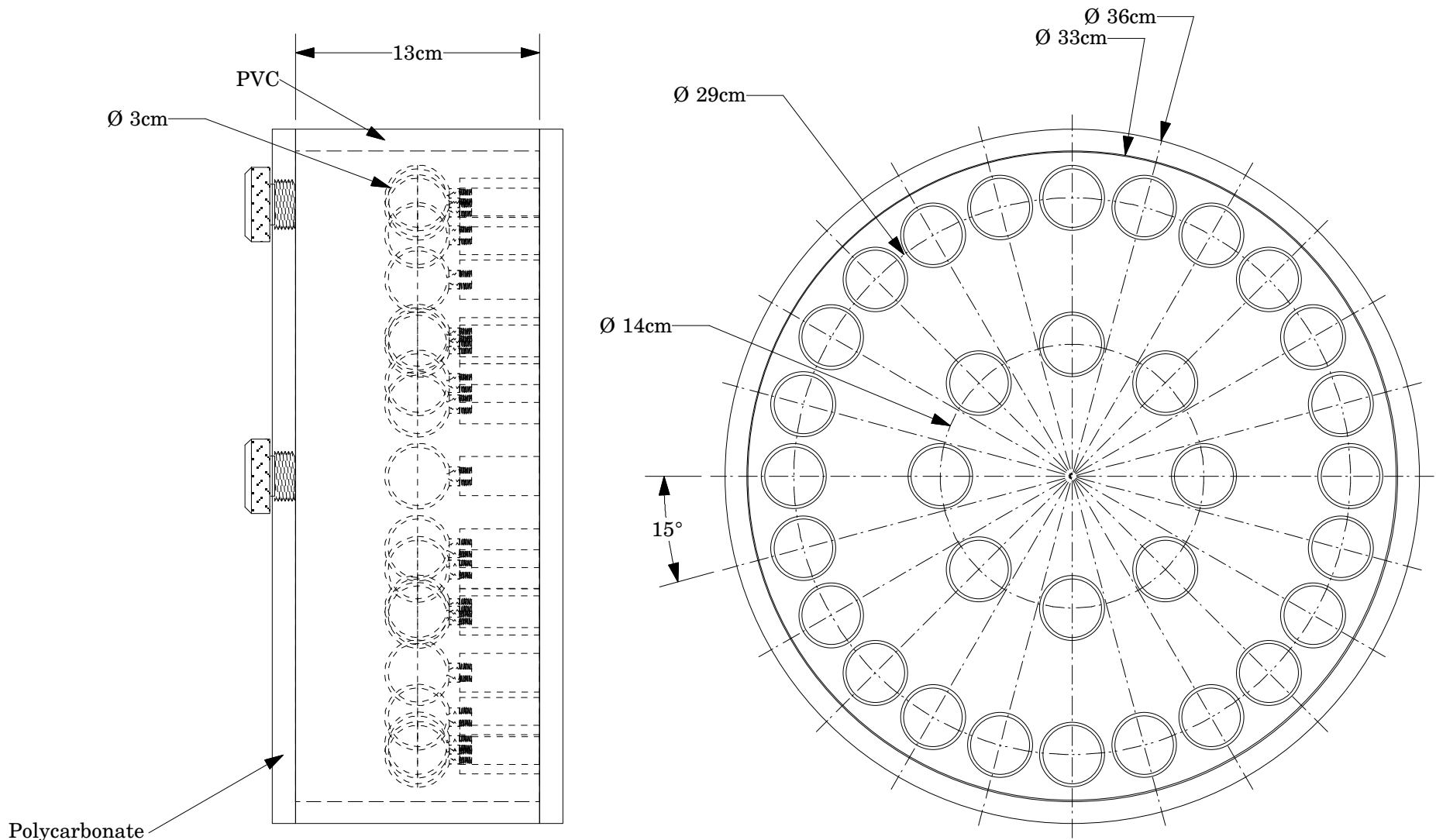
13cm

PVC

Ø 3cm

Ø 36cm

Ø 33cm

Ø 29cm

Ø 14cm

15°

Polycarbonate

Tissue						VIF					
T1 (ms)	R1 (s-1)	Delta R1	[NiCl2] mM	NiCl2 mg/L	NiCl2 mg/sphere	R1 (s-1)	T1 (ms)	Delta R1	[NiCl2] mM	NiCl2 mg/L	NiCl2 mg/sphere
1500.0	0.67	0.00	1.075	139.35	1.97	0.75	1333.3	0.00	1.210	156.77	2.22
1060.7	0.94	0.28	1.521	197.08	2.79	2.63	381.0	1.88	4.234	548.71	7.76
750.0	1.33	0.67	2.151	278.71	3.94	6.56	152.4	5.81	10.585	1371.77	19.39
530.3	1.89	1.22	3.041	394.16	5.57	11.56	86.5	10.81	18.649	2416.94	34.17
375.0	2.67	2.00	4.301	557.42	7.88	17.56	56.9	16.81	28.327	3671.13	51.90
265.2	3.77	3.10	6.083	788.31	11.14	24.56	40.7	23.81	39.617	5134.35	72.59
187.5	5.33	4.67	8.602	1114.84	15.76	32.56	30.7	31.81	52.520	6806.61	96.23
132.6	7.54	6.88	12.165	1576.62	22.29	41.56	24.1	40.81	67.036	8687.90	122.82

r1 (NiCl2)   0.62 mM-1 s-1   71.34 mg NiCl2 per group of 8 spheres   407.07 mg

214.03 mg NicCl2 for 3 groups of spheres

Volume of sphere: 14.13717 mL (3-cm diameter)
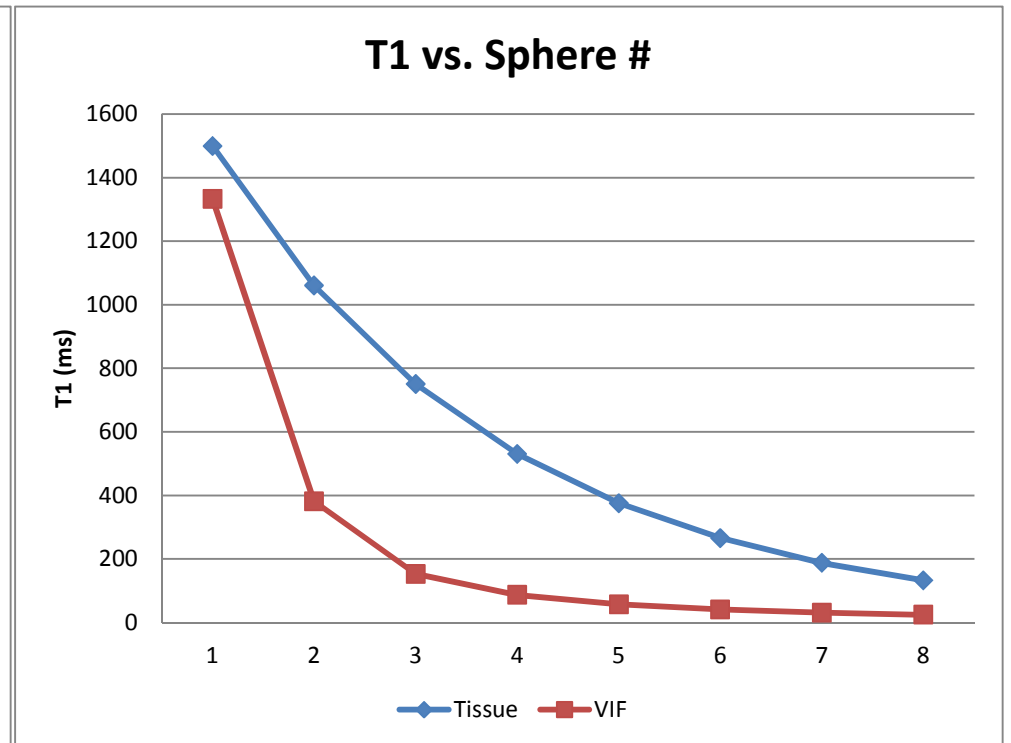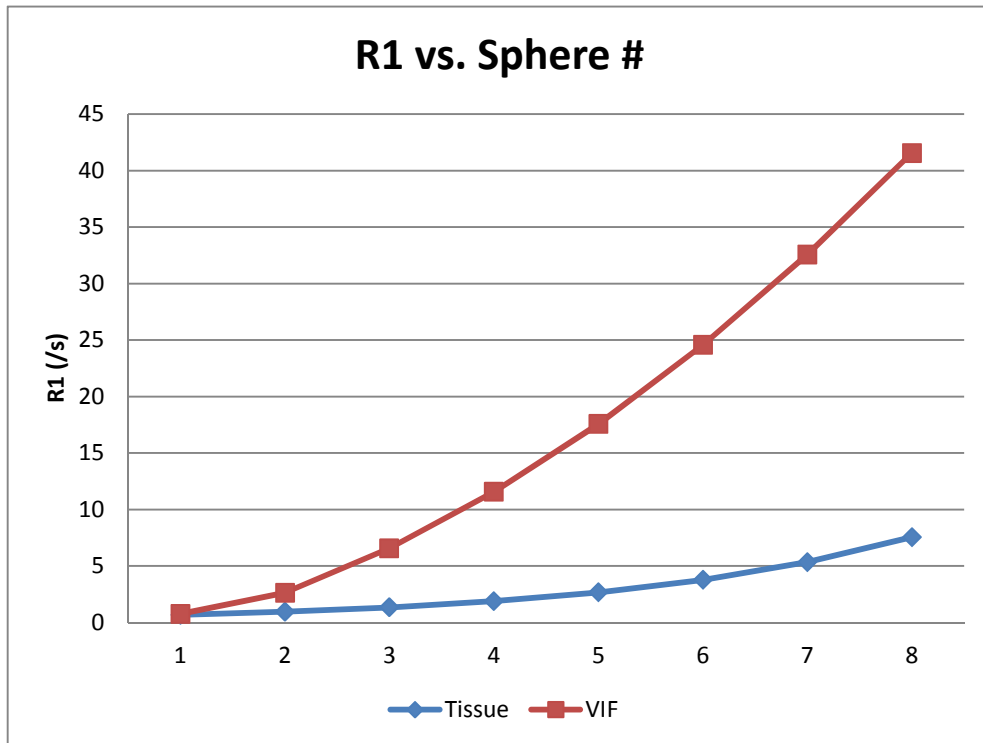
R1 vs. Sphere #

T1 vs. Sphere #

VFA R1 Analysis (Using Output from VirtualScopics QIBA Code)

No Correction

| Phantom ROI	VIF R1 (/s)	VIF M0	Rotation 1 R1 (/s)	Rotation 1 M0	Rotation 2 R1 (/s)	Rotation 2 M0	Rotation 3 R1 (/s)	Rotation 3 M0	Ave R1 (/s)	Ave Stdev (/s)	Ave M0	Ave Stdev
1	0.95	3238	2.03	1950	1.02	4661	1.43	3730	1.49	0.51	3447	1378
2	2.55	3693	1.62	3636	1.85	4331	1.25	3999	1.57	0.30	3989	348
3	6.25	4373	1.71	3856	2.81	3329	1.82	3028	2.11	0.61	3405	419
4	12.49	4796	2.69	4755	2.27	4253	4.26	2101	3.08	1.05	3703	1410
5	19.22	4276	5.67	3145	3.28	2845	5.04	3036	4.67	1.24	3009	152
6	26.82	4303	5.20	3985	7.02	2580	4.72	3374	5.65	1.21	3313	705
7	33.43	3773	6.32	3160	11.81	2322	6.72	4800	8.28	3.06	3427	1260
8	46.61	3120	11.75	2928	10.25	3534	15.08	3493	12.36	2.47	3318	339
Stdev M0:		588		835		870		791			290	

Phantom ROI	Actual R1 VIF	Actual R1 Tissue	Average R1 VIF	Average R1 Tissue	Difference R1 VIF	Difference R1 Tissue
1	1.05	0.97	1.00	1.23	-0.100	0.524
2	2.92	1.37	2.74	1.47	-0.379	0.205
3	6.86	1.93	6.55	2.02	-0.618	0.177
4	11.86	2.73	12.18	2.90	0.630	0.341
5	17.86	3.87	18.54	4.27	1.365	0.800
6	24.88	5.47	25.85	5.56	1.947	0.180
7	32.89	7.73	33.16	8.01	0.540	0.551
8	41.84	10.94	44.23	11.65	4.772	1.419
Limits of agreement:					3.42	0.83

With Correction

Phantom ROI	VIF R1 (/s)	VIF M0	Rotation 1 R1 (/s)	Rotation 1 M0	Rotation 2 R1 (/s)	Rotation 2 M0	Rotation 3 R1 (/s)	Rotation 3 M0	Ave R1 (/s)	Ave Stdev (/s)	Ave M0	Ave Stdev
1	0.95	3977	2.04	2007	1.01	3636	1.42	3254	1.49	0.51	2966	852
2	2.55	4048	1.62	2907	1.85	3283	1.24	3527	1.57	0.30	3239	312
3	6.25	4228	1.71	3396	2.81	2890	1.81	3031	2.11	0.61	3106	261
4	12.52	4251	2.69	3586	2.27	3620	4.28	2066	3.08	1.06	3091	887
5	19.27	4163	5.69	2691	3.29	3099	5.06	2483	4.68	1.25	2758	313
6	26.91	4131	5.21	3473	7.04	2380	4.73	3185	5.66	1.22	3013	567
7	33.56	3940	6.34	3198	11.89	2139	6.73	3603	8.32	3.10	2980	756
8	46.75	3628	11.78	2713	10.27	3041	15.14	2770	12.40	2.49	2841	175
Stdev M0:		202		526		537		525			152	

Phantom ROI	Actual R1 VIF	Actual R1 Tissue	Average R1 VIF	Average R1 Tissue	Difference R1 VIF	Difference R1 Tissue
1	1.05	0.97	1.00	1.23	-0.100	0.525
2	2.92	1.37	2.74	1.47	-0.378	0.203
3	6.86	1.93	6.56	2.02	-0.609	0.177
4	11.86	2.73	12.19	2.91	0.657	0.347
5	17.86	3.87	18.56	4.27	1.410	0.812
6	24.88	5.47	25.89	5.56	2.030	0.194
7	32.89	7.73	33.22	8.03	0.660	0.584
8	41.84	10.94	44.30	11.67	4.909	1.456
Limits of agreement:					3.51	0.85
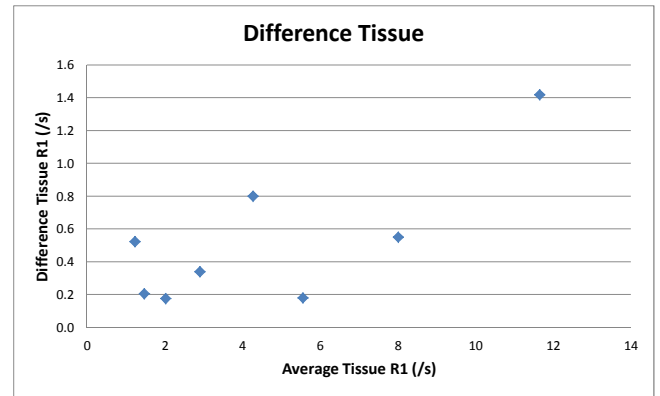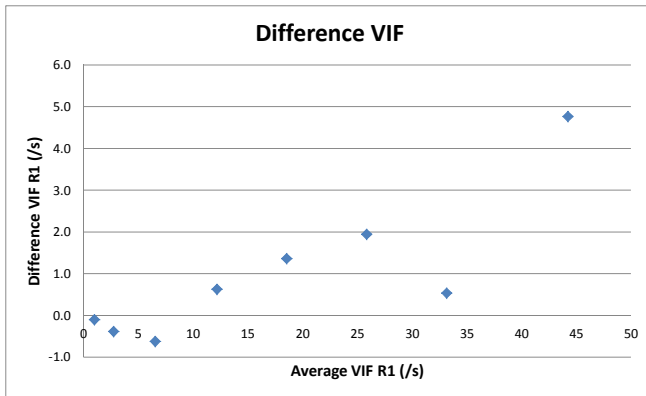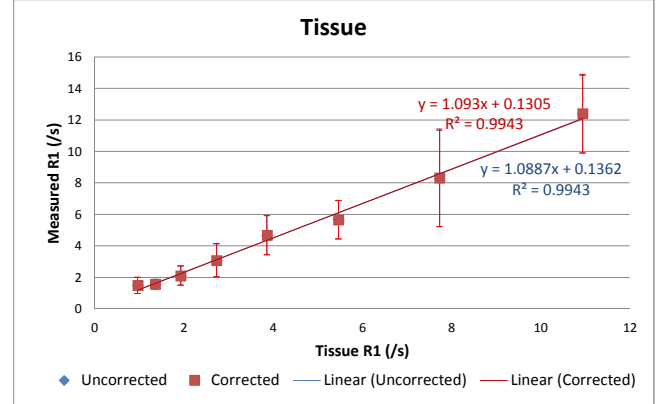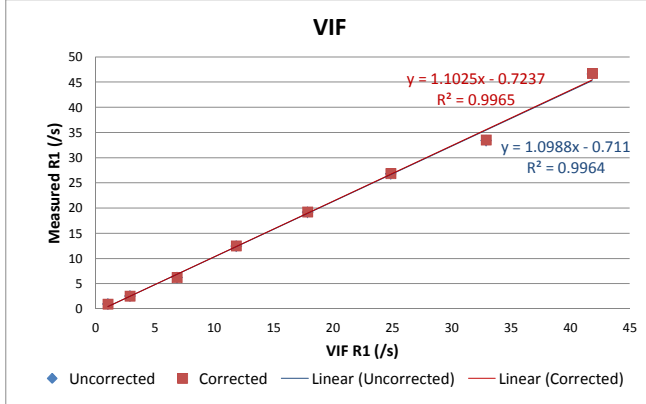
VIF

$y = 1.1025x - 0.7237$
$R^2 = 0.9965$

$y = 1.0988x - 0.711$
$R^2 = 0.9964$

Measured R1 (/s) vs VIF R1 (/s)

♦ Uncorrected   ■ Corrected   — Linear (Uncorrected)   — Linear (Corrected)

Tissue

$y = 1.093x + 0.1305$
$R^2 = 0.9943$

$y = 1.0887x + 0.1362$
$R^2 = 0.9943$

Measured R1 (/s) vs Tissue R1 (/s)

♦ Uncorrected   ■ Corrected   — Linear (Uncorrected)   — Linear (Corrected)

Difference VIF

Difference VIF R1 (/s) vs Average VIF R1 (/s)

Difference Tissue

Difference Tissue R1 (/s) vs Average Tissue R1 (/s)

DCE Analysis (Using Output from VirtualScopics QIBA Code)

No Correction

Phantom ROI	VIF Signal Intensity				Rotation 1 Signal Intensity				Rotation 2 Signal Intensity				Rotation 3 Signal Intensity				Ave Across Rotations				Actual R1 (/s)	
	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV**	SNR	VIF	Tissue
1	44.0	0.38	0.86	30.7	56.1	0.24	0.42	50.7	68.8	0.32	0.47	38.6	77.3	0.42	0.54	53.8	67.4	10.70	15.87	47.7	1.05	0.97
2	132.4	0.33	0.25	75.9	82.6	0.55	0.67	43.6	118.4	0.38	0.32	75.7	72.9	0.25	0.35	44.4	91.3	23.99	26.27	54.6	2.92	1.37
3	357.8	0.39	0.11	208.7	94.2	0.39	0.42	50.0	133.5	0.83	0.62	108.2	79.5	0.39	0.49	39.9	102.4	27.93	27.28	66.0	6.86	1.93
4	689.9	0.36	0.05	450.3	184.2	0.36	0.20	110.7	139.7	0.33	0.24	84.9	123.3	0.50	0.41	102.4	149.1	31.48	21.12	99.3	11.86	2.73
5	829.9	0.97	0.12	608.1	242.3	1.03	0.42	214.3	132.8	0.42	0.32	63.6	202.4	0.65	0.32	123.8	192.5	55.42	28.79	133.9	17.86	3.87
6	1027.4	0.92	0.09	738.6	280.8	0.78	0.28	180.7	234.6	0.89	0.38	164.6	214.7	0.76	0.36	101.2	243.4	33.92	13.94	148.8	24.88	5.47
7	1018.0	1.02	0.10	624.9	266.1	0.48	0.18	141.8	314.9	0.33	0.11	241.8	424.6	0.53	0.13	236.8	335.2	81.19	24.22	206.8	32.89	7.73
8	981.6	3.37	0.34	610.7	402.0	1.38	0.34	228.4	431.2	1.81	0.42	195.6	589.8	0.63	0.11	428.1	474.3	101.06	21.31	284.0	41.84	10.94
Averages:			0.24				0.37				0.36				0.34				22.35			

With Correction

Phantom ROI	VIF Signal Intensity				Rotation 1 Signal Intensity				Rotation 2 Signal Intensity				Rotation 3 Signal Intensity				Ave Across Rotations			
	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV*	SNR	Average	Stdev	%COV**	SNR
1	53.6	0.46	0.86	30.1	57.6	0.24	0.42	50.9	53.2	0.25	0.48	37.6	66.8	0.38	0.56	51.6	59.2	6.93	11.71	46.7
2	144.6	0.36	0.25	74.4	65.5	0.44	0.68	42.4	88.6	0.28	0.32	73.2	63.8	0.23	0.36	43.3	72.6	13.87	19.10	52.9
3	345.9	0.38	0.11	207.6	82.7	0.35	0.42	48.6	114.9	0.72	0.62	104.6	79.3	0.39	0.50	39.4	92.3	19.66	21.29	64.2
4	610.4	0.33	0.05	436.9	138.4	0.28	0.20	107.6	118.7	0.28	0.24	83.4	121.3	0.50	0.41	101.7	126.1	10.70	8.49	97.6
5	808.6	0.94	0.12	604.9	206.0	0.87	0.42	208.0	144.6	0.46	0.32	62.5	164.9	0.53	0.32	121.1	171.8	31.30	18.21	130.5
6	985.8	0.89	0.09	730.1	245.0	0.69	0.28	177.3	216.3	0.83	0.38	161.3	202.8	0.73	0.36	99.8	221.4	21.55	9.73	146.1
7	1061.7	1.06	0.10	622.5	269.5	0.49	0.18	140.8	288.9	0.30	0.11	239.5	317.9	0.40	0.12	230.9	292.1	24.39	8.35	203.7
8	1143.6	3.93	0.34	602.6	373.1	1.28	0.34	226.9	369.4	1.55	0.42	193.0	462.4	0.50	0.11	414.4	401.6	52.65	13.11	278.1
Averages:			0.24				0.37				0.36				0.34				13.75	

VIF — Signal Intensity (a.u.) vs VIF R1 (/s). ◆ Uncorrected ■ Corrected

Tissue — Signal Intensity (a.u.) vs Tissue R1 (/s).
$y = 40.007x + 31.867$, $R^2 = 0.9979$
$y = 34.266x + 29.686$, $R^2 = 0.9982$
◆ Uncorrected ■ Corrected — Linear (Uncorrected) — Linear (Corrected)
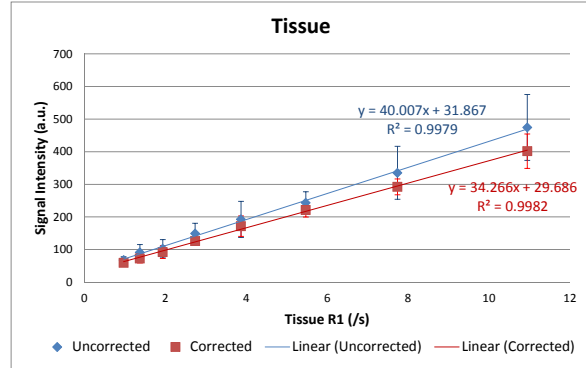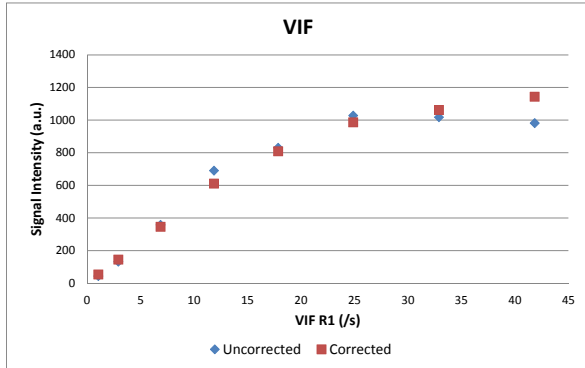
* Percent coefficient of variation across all timepoints in the DCE acquisition
** Percent coefficient of variation across all three pseudorotations of the tissue compartments

VirtualScopics VFA T1 Measurement Output (With and Without Ratio Map Correction)

	No Correction			Corrected		
Region	T1	M0	MMSE	Region	T1	M0	MMSE
1	37.2824	4302.6	111.258	1	37.1671	4130.96	111.652
2	52.0224	4275.53	59.7945	2	51.9021	4163.34	60.396
3	80.0468	4795.95	55.1008	3	79.8764	4250.64	45.9115
4	160.109	4373.15	26.446	4	159.88	4228.14	25.5333
5	392.875	3693.45	8.57352	5	392.7	4048.44	10.5667
6	1053.15	3238.41	1.77331	6	1056.78	3977	2.76342
7	21.4533	3119.85	514.659	7	21.3902	3628.26	744.428
8	29.9091	3772.73	236.41	8	29.8017	3939.94	278.193
9	192.26	3985.23	8.93477	9	191.831	3473.3	7.16749
10	701.014	3730.19	1.17358	10	702.105	3253.92	0.94721
11	356.274	3328.92	1.0065	11	355.932	2889.91	0.820393
12	176.254	3144.84	0.843118	12	175.71	2691.11	0.691806
13	66.3136	3493.18	2.5285	13	66.0414	2770.21	1.4237
14	541.362	4331.27	2.71792	14	541.671	3282.76	1.63347
15	372.185	4754.53	7.46144	15	371.968	3585.63	4.39587
16	148.796	4799.7	23.2879	16	148.552	3603.37	13.7714
17	983.377	4660.73	2.23805	17	986.285	3636.43	1.42292
18	585.433	3856.46	3.57964	18	585.423	3396.42	2.88235
19	211.864	3374.02	14.6127	19	211.428	3185.49	13.6448
20	97.543	3534.06	64.4874	20	97.3277	3040.76	49.9005
21	615.816	3635.96	4.76722	21	616.515	2906.96	3.15966
22	198.256	3036.12	17.2186	22	197.736	2482.82	12.1204
23	84.6579	2322.3	28.268	23	84.1268	2138.89	26.8214
24	493.001	1949.64	1.14976	24	490.927	2007.05	1.31276
25	234.47	2101.34	4.46314	25	233.638	2066.25	4.64547
26	142.444	2580.18	18.771	26	141.995	2379.99	17.0717
27	85.1247	2927.66	60.1963	27	84.923	2713.02	54.1118
28	550.941	3028.25	3.68737	28	551.318	3030.94	3.82669
29	304.439	2844.78	6.09679	29	304.2	3098.61	7.45598
30	158.214	3160.23	10.9688	30	157.823	3198.24	11.9604
31	802.746	3998.94	2.16194	31	804.391	3526.52	1.75654
32	439.865	4253.33	5.19146	32	439.636	3620.06	3.90614

VirtualScopics DCE Measurement Output (With and Without Ratio Map Correction)

No Correction					**With Correction**				
Source ROI	Average	Stdev	%COV	SNR	Source ROI	Average	Stdev	%COV	SNR
1	1027.4	0.92	0.090	738.6	1	985.8	0.89	0.090	730.1
2	829.9	0.97	0.117	608.1	2	808.6	0.94	0.117	604.9
3	689.9	0.36	0.053	450.3	3	610.4	0.33	0.054	436.9
4	357.8	0.39	0.109	208.7	4	345.9	0.38	0.109	207.6
5	132.4	0.33	0.249	75.9	5	144.6	0.36	0.250	74.4
6	44.0	0.38	0.857	30.7	6	53.6	0.46	0.861	30.1
7	981.6	3.37	0.344	610.7	7	1143.6	3.93	0.344	602.6
8	1018.0	1.02	0.100	624.9	8	1061.7	1.06	0.100	622.5
9	280.8	0.78	0.279	180.7	9	245.0	0.69	0.280	177.3
10	77.3	0.42	0.545	53.8	10	66.8	0.38	0.564	51.6
11	133.5	0.83	0.622	108.2	11	114.9	0.72	0.623	104.6
12	242.3	1.03	0.424	214.3	12	206.0	0.87	0.421	208.0
13	589.8	0.63	0.106	428.1	13	462.4	0.50	0.107	414.4
14	118.4	0.38	0.321	75.7	14	88.6	0.28	0.320	73.2
15	184.2	0.36	0.198	110.7	15	138.4	0.28	0.201	107.6
16	424.6	0.53	0.125	236.8	16	317.9	0.40	0.125	230.9
17	68.8	0.32	0.472	38.6	17	53.2	0.25	0.475	37.6
18	94.2	0.39	0.418	50.0	18	82.7	0.35	0.425	48.6
19	214.7	0.76	0.355	101.2	19	202.8	0.73	0.358	99.8
20	431.2	1.81	0.419	195.6	20	369.4	1.55	0.420	193.0
21	82.6	0.55	0.671	43.6	21	65.5	0.44	0.678	42.4
22	202.4	0.65	0.319	123.8	22	164.9	0.53	0.320	121.1
23	314.9	0.33	0.106	241.8	23	288.9	0.30	0.105	239.5
24	56.1	0.24	0.422	50.7	24	57.6	0.24	0.417	50.9
25	123.3	0.50	0.409	102.4	25	121.3	0.50	0.411	101.7
26	234.6	0.89	0.381	164.6	26	216.3	0.83	0.383	161.3
27	402.0	1.38	0.344	228.4	27	373.1	1.28	0.344	226.9
28	79.5	0.39	0.491	39.9	28	79.3	0.39	0.496	39.4
29	132.8	0.42	0.319	63.6	29	144.6	0.46	0.320	62.5
30	266.1	0.48	0.182	141.8	30	269.5	0.49	0.183	140.8
31	72.9	0.25	0.349	44.4	31	63.8	0.23	0.359	43.3
32	139.7	0.33	0.238	84.9	32	118.7	0.28	0.236	83.4

Phantom	VS Code
VIF1	6
VIF2	5
VIF3	4
VIF4	3
VIF5	2
VIF6	1
VIF7	8
VIF8	7
R1-1	24
R1-2	21
R1-3	18
R1-4	15
R1-5	12
R1-6	9
R1-7	30
R1-8	27
R2-1	17
R2-2	14
R2-3	11
R2-4	32
R2-5	29
R2-6	26
R2-7	23
R2-8	20
R3-1	10
R3-2	31
R3-3	28
R3-4	25
R3-5	22
R3-6	19
R3-7	16
R3-8	13