Multi-shot DWI with multiplexed sensitivity encoding (MUSE) versus single-shot DWI in the breast

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Declaration of
Financial Interests or Relationships

Speaker Name: Yuxin Hu

I have the following financial interest or relationship to disclose with regard to the subject matter of this presentation:

Company Name: GE Healthcare
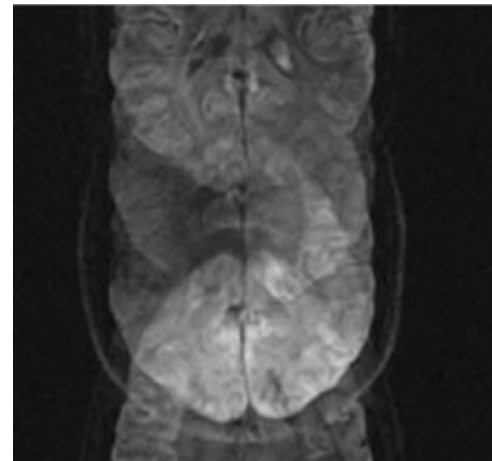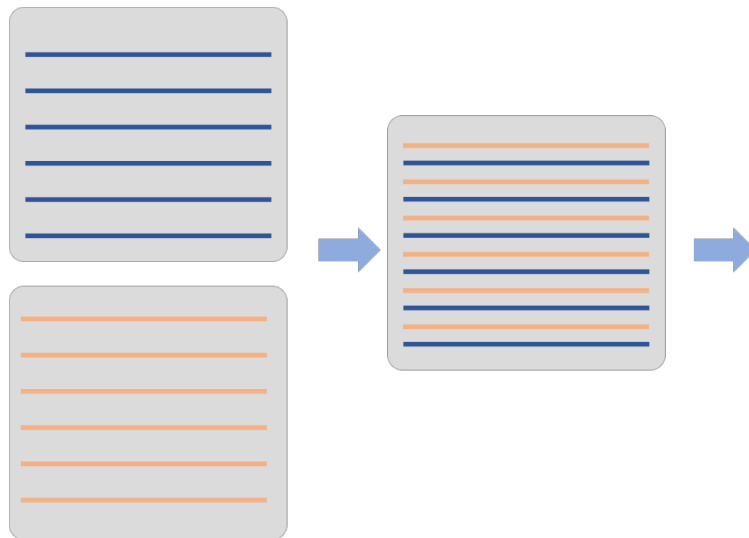Type of Relationship: Research Support

Diffusion-weighted imaging

Single-shot imaging (fast, motion insensitive)

- Limited resolution and SNR

- Heavy distortion

Multi-shot imaging

- Motion sensitive

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Multi-shot DWI

- Motion-induced shot-to-shot phase variations (<u>random</u> and <u>spatially smooth</u>)

- Multiplexed sensitivity encoding (MUSE)
  - Phase estimation for each shot using SENSE

- Shot locally low-rank (shot-LLR)
  - "calibration-less parallel imaging"
  - Spatial-shot matrices
 - Slow-phase variations = low-rank

Chen, Nan-kuei, et al. *Neuroimage* 2013.
Hu, Yuxin, et al. MRM 2019.

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Protocol including multi-shot DWI

	FOV (cm)	#slices	In-plane resolution (mm)	Slice thickness (mm)	b-value (s/mm^2)	#shots	Reduction factor	Repetitions
CUBE	34	204	0.89	2	-	-	-	-
single-shot DWI	34	42	**2.13**	5	0, 600	1	**4**	**8/16**
4-shot DWI	34	42	**1**	5	0, 600	4	**1**	**2**
8-shot DWI	34	42	**1**	5	0, 600	8	**1**	**2**
DCE	34	156	0.66	1.2	-	-	-	-

4-shot results:5 out of 9 cases with tumors/lesions

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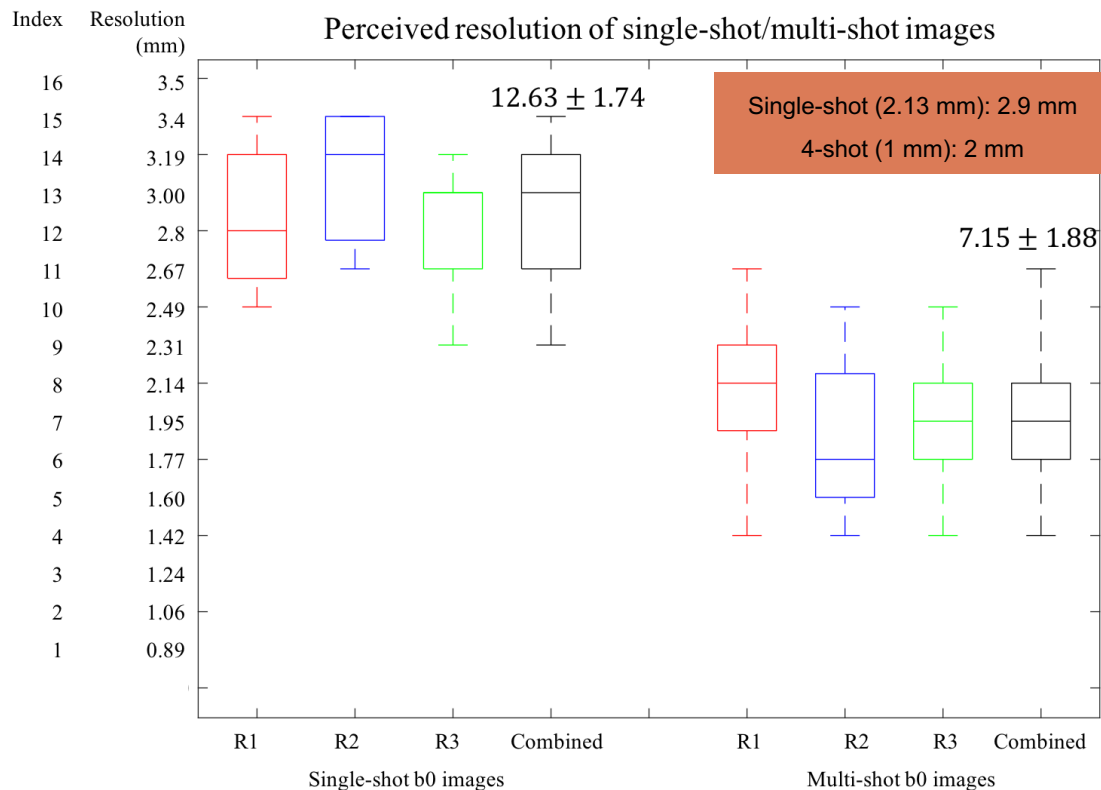
Single-shot

MUSE

DCE
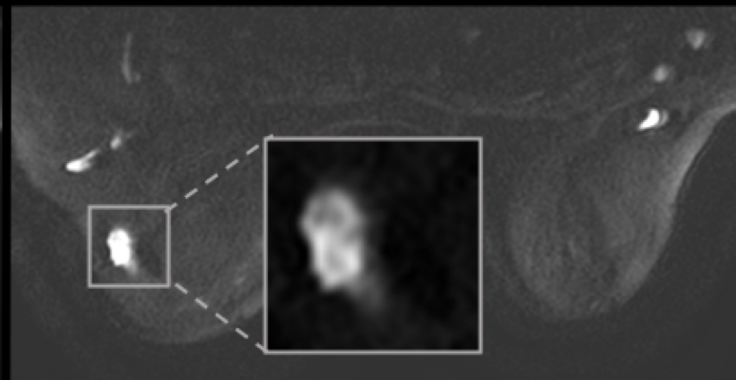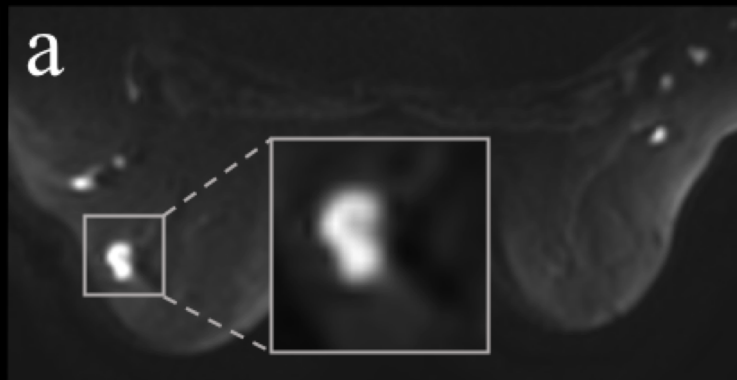
Shot-LLR
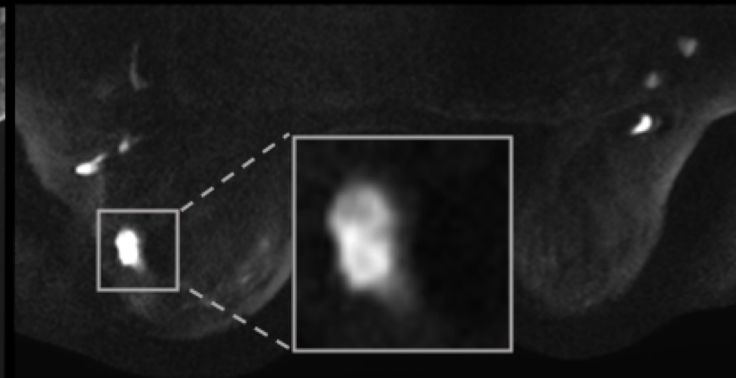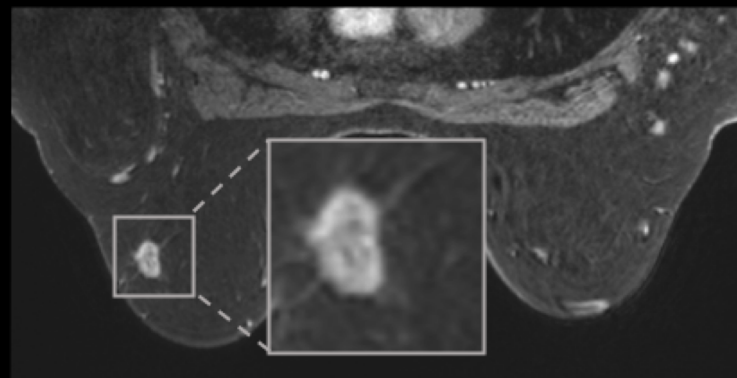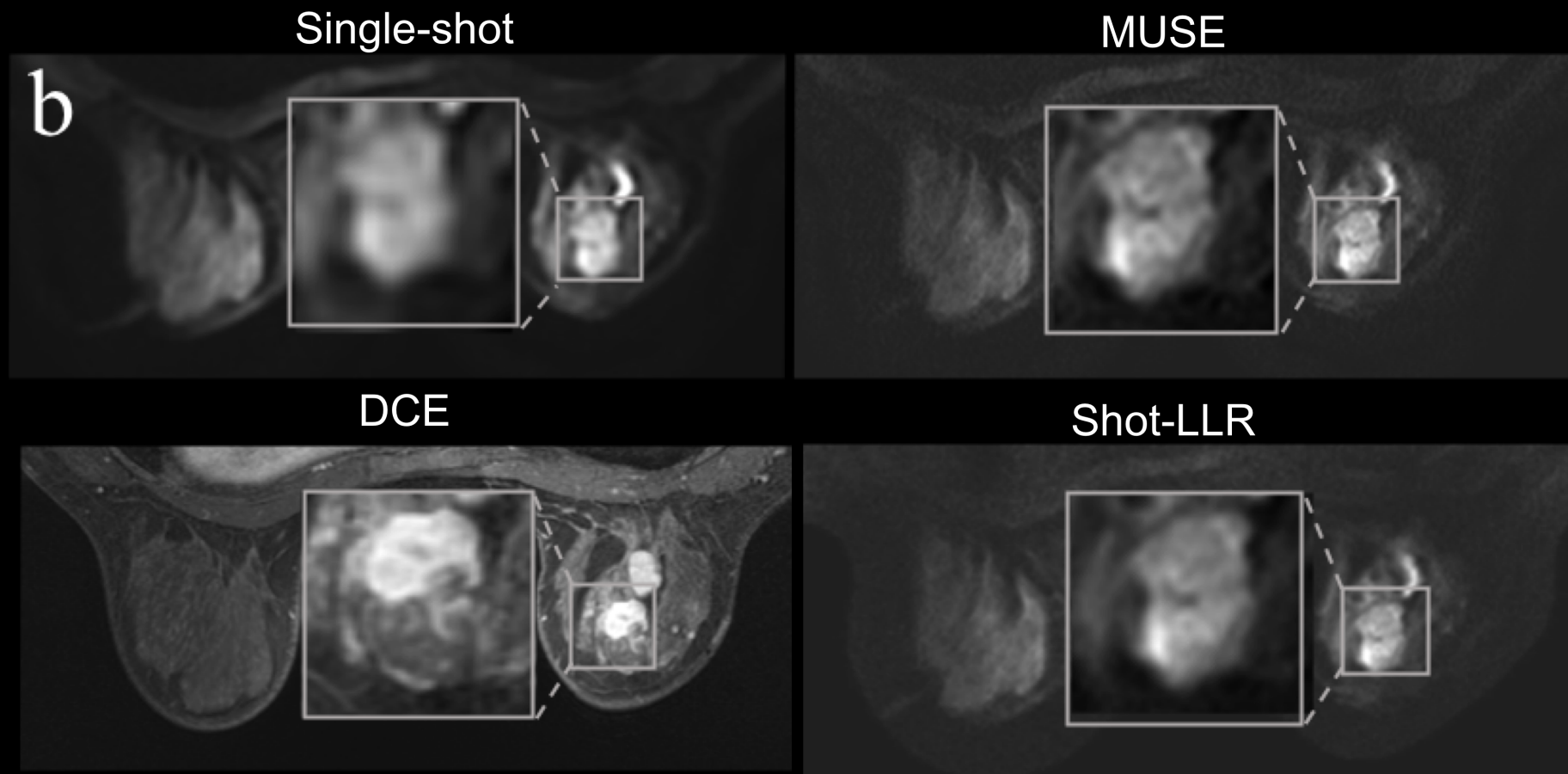
Observer study (9 4-shot cases)

- Perceived resolution (compared with down-sampled CUBE)

- Lesion Conspicuity
- Depiction of lesion detail
- SNR
- Distortion
- Artifacts

Perceived resolution of DWIs

T2 Cube images were down-sampled first along slice encoding direction, then to different in-plane resolutions.

Perceived resolution of single-shot/multi-shot images

Single-shot (2.13 mm): 2.9 mm

4-shot (1 mm): 2 mm

12.63 ± 1.74

7.15 ± 1.88

Index	Resolution (mm)
16	3.5
15	3.4
14	3.19
13	3.00
12	2.8
11	2.67
10	2.49
9	2.31
8	2.14
7	1.95
6	1.77
5	1.60
4	1.42
3	1.24
2	1.06
1	0.89

R1   R2   R3   Combined

Single-shot b0 images

R1   R2   R3   Combined

Multi-shot b0 images

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4-shot results

Multi-shot imaging showed increased lesion conspicuity and depiction of detail compared with single-shot images ($p < 0.05$) .

	Lesion Conspicuity	Depiction of lesion detail	SNR	Distortion	Artifacts
Single-shot	3.1±0.85	2±0.63	2.2±0.54	2.1±0.77	1.8±0.54
MUSE	**3.8±1.11**	**2.9±0.88**	1.7±0.77	2.1±0.85	2.0±0.63
shot-LLR	**3.8±1.04**	**2.9±0.34**	1.8±0.83	2.0±0.82	2.5±0.81

Lesion conspicuity: 3=visible but less bright than contrast-enhanced MRI, 4=equivalent to contrast-enhanced MRI.

Depiction of lesion detail: 2=barely perceptible, 3=visible but less well-defined than on contrast-enhanced MRI, 4=equivalent depiction of lesion morphology to contrast-enhanced MRI.

8-shot results

	Single-shot	MUSE	shot-LLR	DCE
Case 1				
Case 2				
Case 3	i	ii	iii	iv
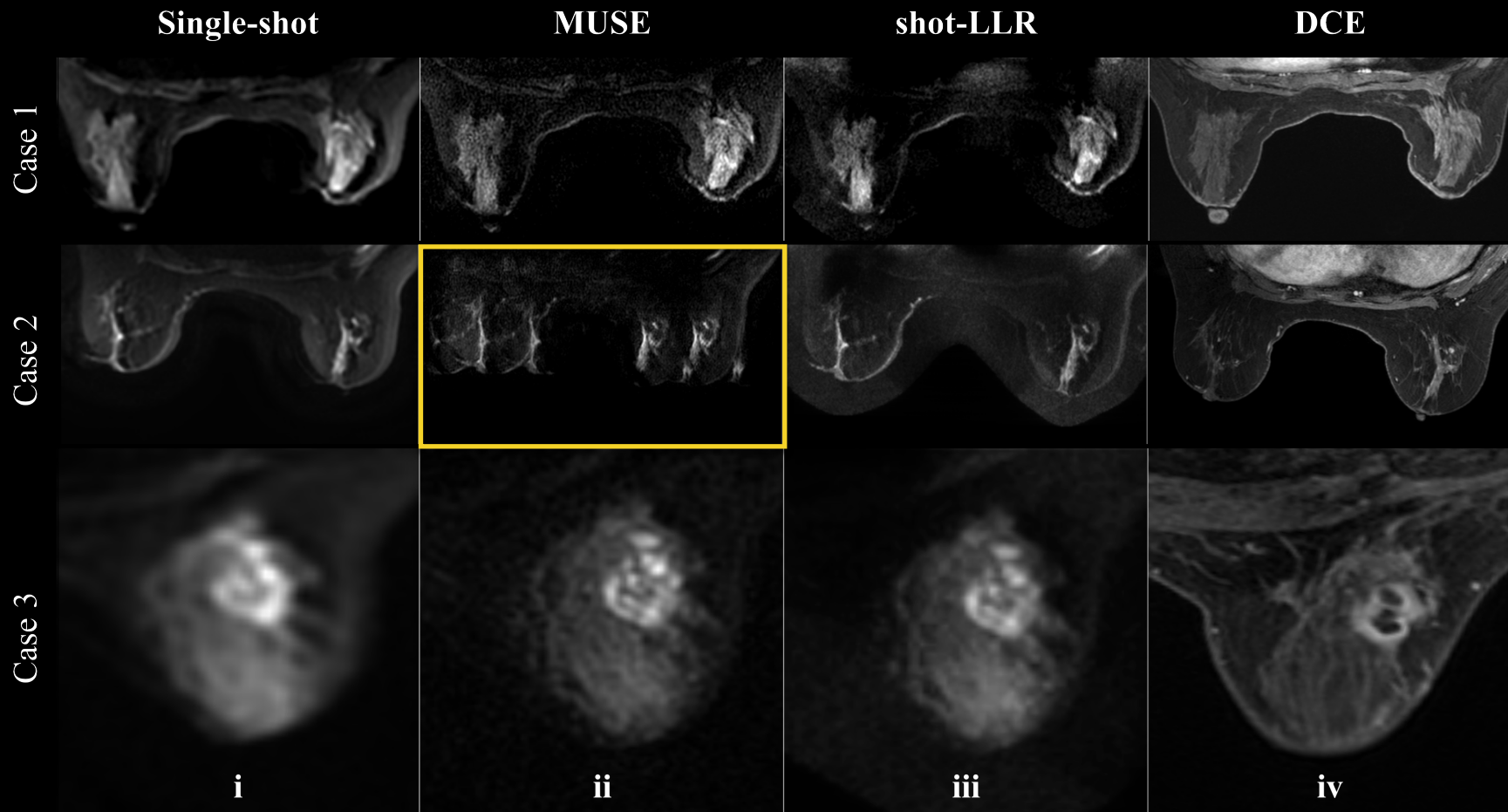
Summary

- Multi-shot imaging enables higher-resolution or reduced off resonance for better diagnosis

- Both MUSE and shot-LLR work well for 4-shot images