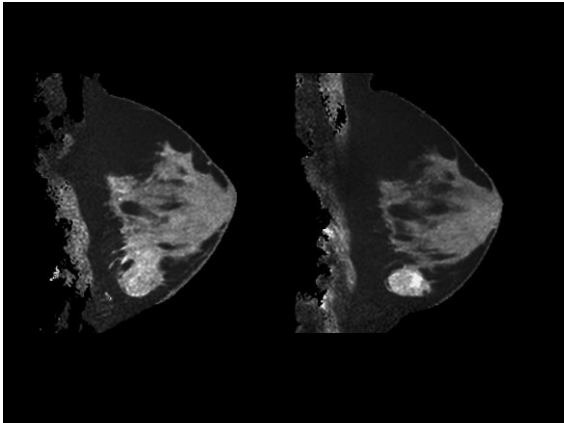


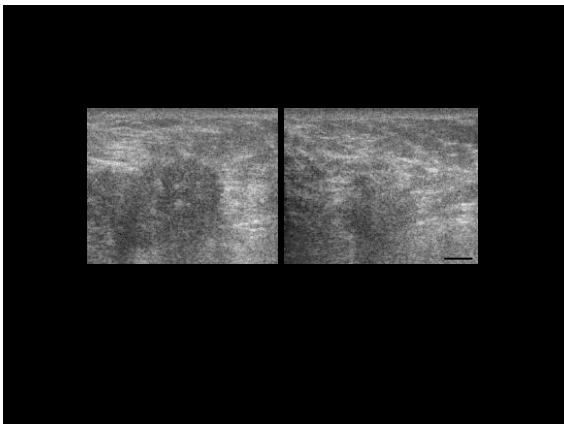
**Ultrasound Innovations for Therapy
Response Monitoring: State of the
Art**

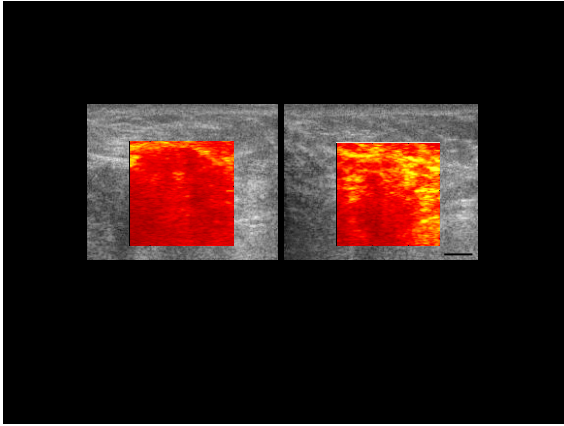
Gregory J. Czarnota Ph.D. M.D.



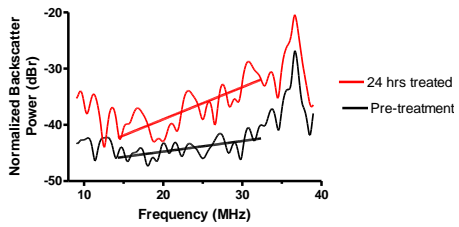
Sunnybrook
HEALTH SCIENCES CENTRE

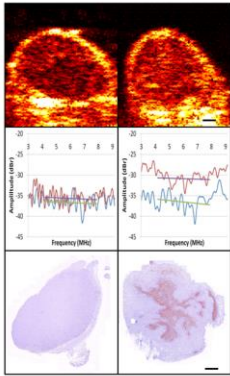












n=90
5 scans per patient
locally advanced breast cancer
neoadjuvant chemotherapy

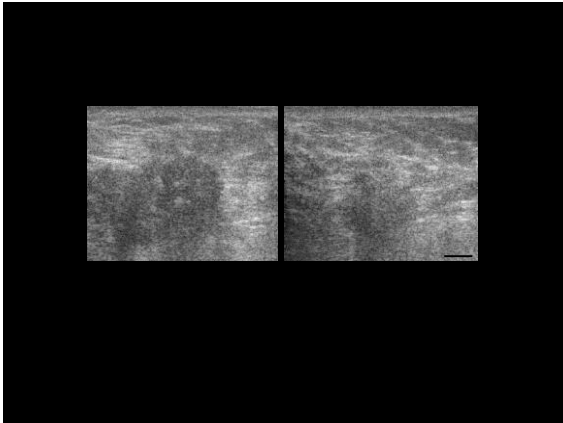


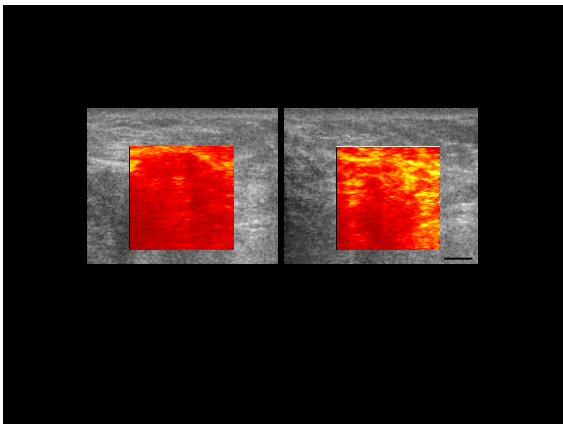
mid-band fit
0-MHz intercept
spectral slope

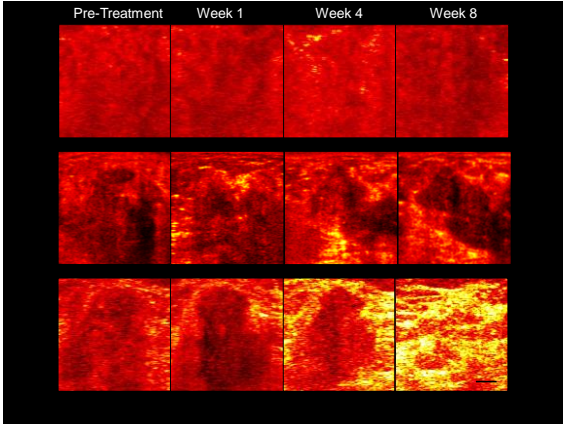
a
c/v

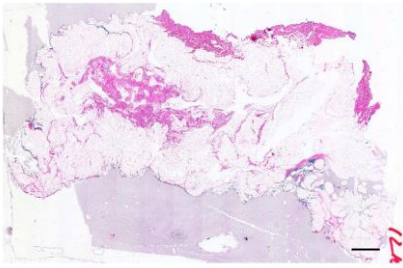


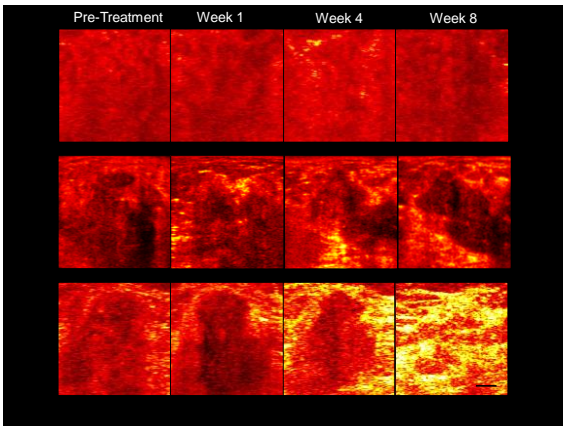
Patient #	Neoadjuvant Treatment	MRI dimensions of tumour (AP X ML X SI)	Pathologic dimensions of tumour (AP X ML X SI)	Notes from Pathology	Response
1	ChemoRT	5 X 4.5 X 4.5	1.8 X 4 X 4.5	Significant in-situ tumour present	Weak pathologic response
2	Sunitinib/Herceptin → Docetaxel/Trastuzumab/ Pamidronate	11.2 X 7.3 X 8.3	N/A	Clinically good response with second chemotherapy regimen	Initial poor clinical response then good clinical response with change in chemo
3	Epirubicin and docetaxel	6.1 X 7.8 X 3.3	5.2 X 7 X 1.8	Minimal response to chemotherapy	Minimal pathologic response
4	ChemoRT	10 X 6"	1 X 1 X 0.7	Very small volume of disease remaining	Good pathologic response
5	Epirubicin and docetaxel	11 X 6.3 X 5.5	4.5 X 4 X 9	Minimal response to chemotherapy	Minimal pathologic response
6	AC + T	7.8 X 4.6 X 5.5	2 X 7 X 3	Nests of tumour occupying a large volume, very minimal tumour cellularity	Good pathologic response
7	AC + T	7.5 X 6.5 X 5.5	8.9 X 7.7 X 3	Tumour cellularity high	Minimal pathologic response
8	ChemoRT	5.1 X 5.5 X 4.5	2.5 X 4.8 X 3.6	Numerous small foci of invasive disease. 10% of tumour invasive.	Good pathologic response
9	Docetaxel/Carboplatinum/ Trastuzumab	4.8 X 3.1 X 5.5	2 X 3 X 6	Very small nests of cells, very marked response	Good pathologic response
10	FEC + D	10.2 X 7.2 X 6.8	1.7 X 6 X 4.5	Invasive tumour is present as single cells only, rare groups of cells.	Good pathologic response

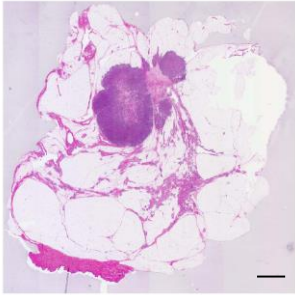


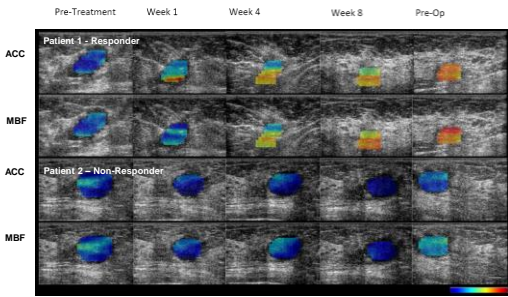


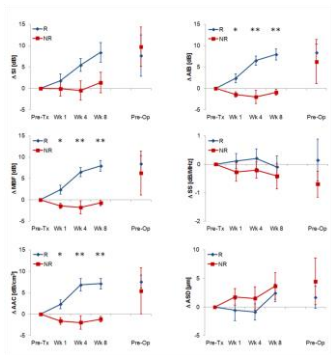


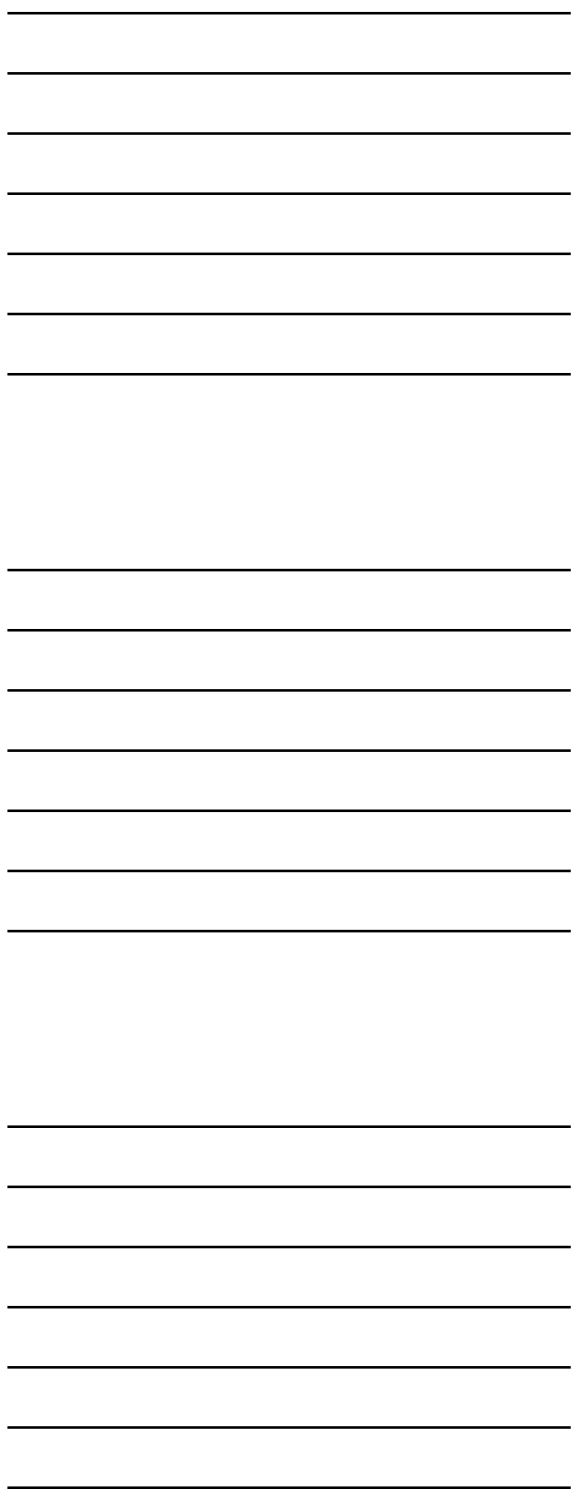
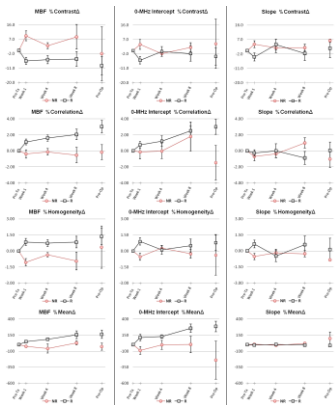
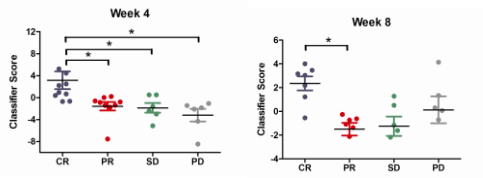
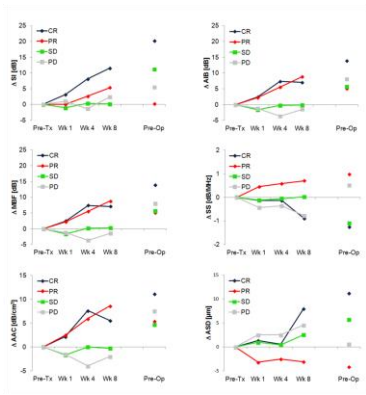


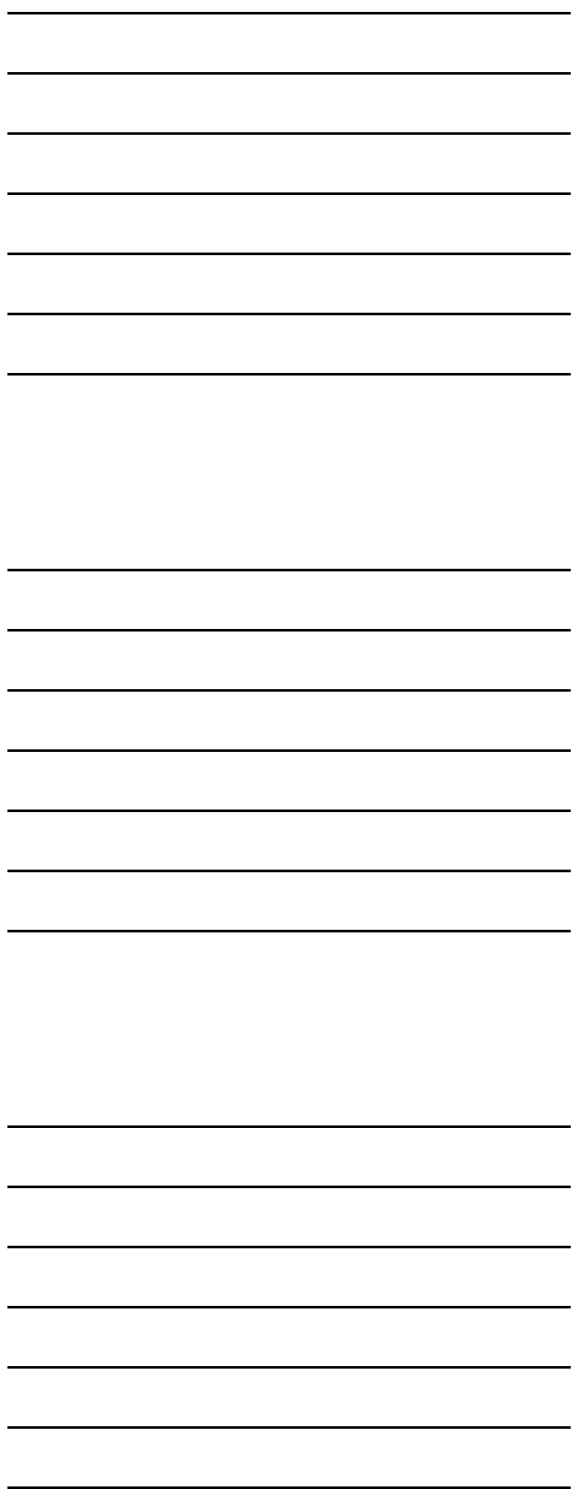
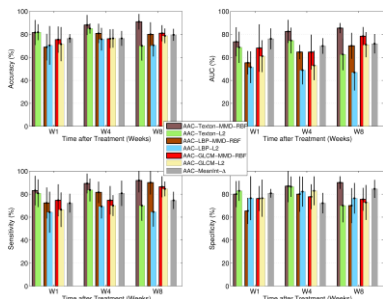
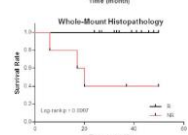
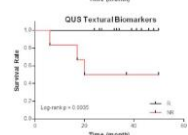
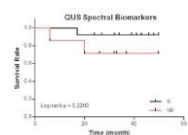
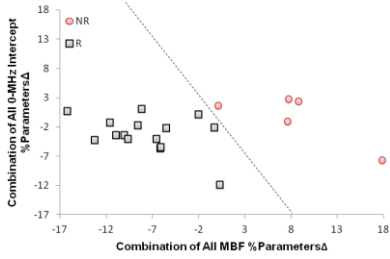






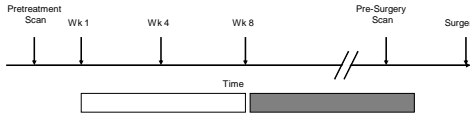






Chemotherapy Personalization

ARM 1:



ARM 2:

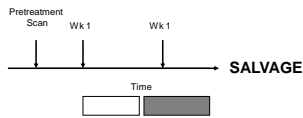


Chemotherapy Personalization

ARM 1:



ARM 2:



Patient #	Neoadjuvant Treatment	MRI dimensions of tumour (AP x ML x SI)	Pathologic dimensions of tumour (AP x ML x SI)	Notes from Pathology	Response
1	ChemoRT	5 X 4.5 X 4.5	1.8 X 4 X 4.5	Significant in-situ tumour present	Weak pathologic response
2	Sutent/Mercaptopin → Docetaxel/Trastuzumab/ Paclitaxel	11.2 X 7.3 X 6.3	N/A	Clinically good response with second chemotherapy regimen	Initial poor clinical response then good clinical response with change in chemo
3	Epirubicin and docetaxel	6.1 X 7.8 X 3.3	5.2 X 7 X 1.8	Minimal response to chemotherapy	Minimal pathologic response
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n=120
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neoadjuvant chemotherapy

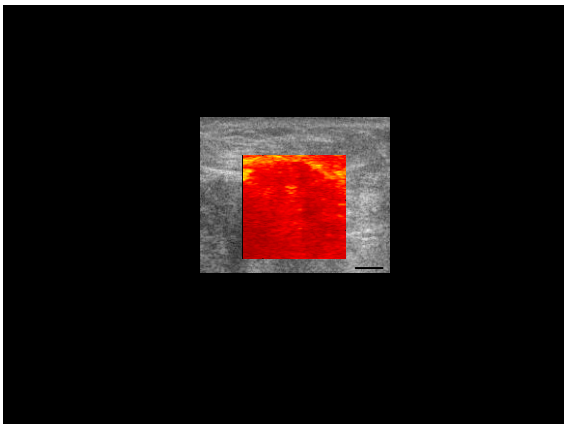


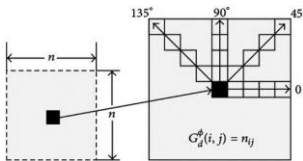
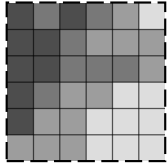
mid-band fit
0-MHz intercept
spectral slope

effective acoustic scatterer size
effective acoustics scatterer concentration

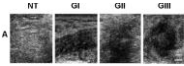
texture

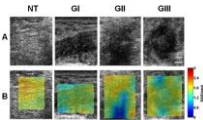


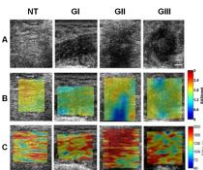


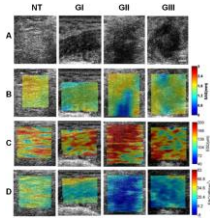


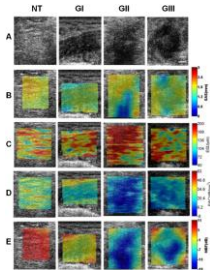
$$\begin{aligned}
 W_1 &= \sum_{i=1}^N \sum_{j=1}^N P^2(i, j) \\
 W_2 &= -\sum_{i=1}^N \sum_{j=1}^N P(i, j) \cdot \ln P(i, j) & u_x &= \sum_{i=1}^N \sum_{j=1}^N P(i, j) \cdot u_x, u_y = \sum_{i=1}^N \sum_{j=1}^N P(i, j) \\
 W_3 &= \sum_{i=1}^N \sum_{j=1}^N (i-j)^2 \cdot P(i, j) & \sigma_x &= \sum_{i=1}^N (i-u_x)^2 \sum_{j=1}^N P(i, j) \\
 W_4 &= \sum_{i=1}^N \sum_{j=1}^N \frac{1}{1+(i-j)^2} P(i, j) & \sigma_y &= \sum_{j=1}^N (j-u_y)^2 \sum_{i=1}^N P(i, j) \\
 W_5 &= \frac{1}{\sigma_x \sigma_y} \sum_{i=1}^N \sum_{j=1}^N (i-u_x)(j-u_y) P(i, j)
 \end{aligned}$$

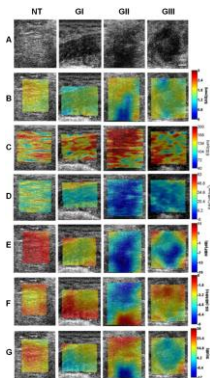


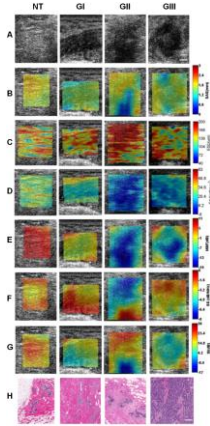


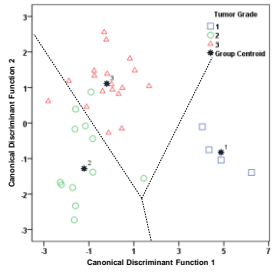












mid-band fit
0-MHz intercept
spectral slope

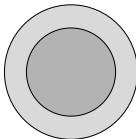
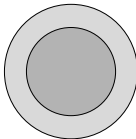
effective acoustic scatterer size
effective acoustic scatterer concentration

texture



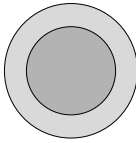
Patient Characteristics:

Number	56
Age	49 +/- 10
Tumour Size	6.3 +/- 4.2 cm
Tumour Type	
IDC	52 (93%)
ILC	3 (5%)
Other	1 (2%)
Responders	42 (72%)
Non-responders	17 (28%)

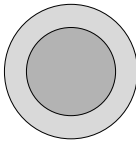


- mid-band fit
- 0-MHz intercept
- spectral slope

- effective acoustic scatterer size
- effective acoustic scatterer concentration



contrast
 correlation
 energy
 homogeneity

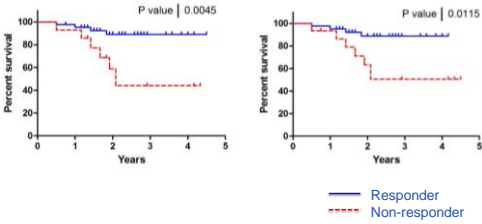


$$SNR = \frac{\mu(ROI_{core})}{\sigma(ROI_{rim})}$$

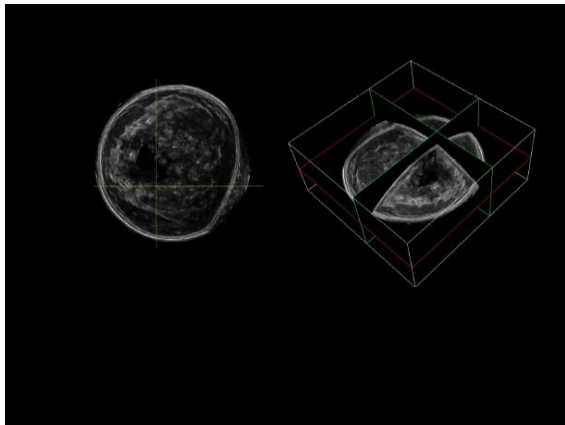
$$CNR = \frac{|\mu(ROI_{core}) - \mu(ROI_{rim})|}{\frac{1}{2}(\sigma(ROI_{core}) + \sigma(ROI_{rim}))}$$

Hybrid Biomarker	
Parameter	p
ACE	0.02
Mean (SI margin)	0.12
Homogeneity (SI core)	0.18
Mean (MBF core)	0.19
SNR (SI)	0.19
CNR (ASD)	0.24
COR (SS core)	0.24
CNR (SI)	0.30
CNR (SS)	0.37

Classifier:	Outcomes:		
	Sensitivity	Specificity	Accuracy
FLD	79	64	75
SVM	90	64	82
KNN	90	79	88







Muhammad Azrif
Shawn Ranieri
Mike Papanicolau
Behzad Banihashemi
Justin Lee
Anoja Giles
Ervis Sofronis
William Tran
Melissa Furukawa
Hani Soliman

Sonal Gandhi M.D.
Maureen Trudeau M.D.
Claire Holloway Ph.D. M.D.
Jean Fancois Boileau M.D.
Kathleen Pritchard M.D.

Michael Kolios Ph.D.
Martin Yaffe Ph.D.

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