Evaluation of 3T multiparametric MRI with radiomic analysis for differentiating benign and malignant breast lesions

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**Operational Programme
Human Resources Development,
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Co-financed by Greece and the European Union

ΕΣΠΑ
2014-2020
ανάπτυξη - εργασία - αλληλεγγύη

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** I do not have any conflict of interest to disclose

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Background

- Differentiation of benign and malignant breast lesions is important for adopting efficient treatment strategies

- The advent of Perfusion and Diffusion MRI techniques has offered new tools for breast tumors radiologic evaluation

- Previous studies have reported the contribution of Radiomic Analysis in the quantitative assessment of tumor heterogeneity

- Most Radiomic studies have relied on individual advanced MRI sequences for building classification models

Purpose

- To evaluate an integrative multiparametric MRI radiomic model, including conventional and advanced techniques, for breast cancer classification

Patient cohort

- 54 benign & 55 malignant biopsy-proven mass-like breast lesions from 109 female patients

- Patient informed consent was obtained

MRI protocol

- 3T MRI system (Signa HDx, GE Healthcare, Milwaukee, WI, USA)

- Axial T2-weighted fast spin echo (T2-FSE) sequence
  (TE 100 ms, TR 3.600 ms, matrix size 512×512, slice thickness 4 mm)

- 3D fat-suppressed T1-weighted (3D-T1-FS) VIBRANT dynamic sequence
  (10o flip angle, TE 2 ms, TR 4.900 ms, matrix size 512×512, voxel size 1 mm isotropic)

- Axial DWI using 2D spin-echo (single-shot) echo-planar imaging and b values of 0 and 850 s^2/mm
  (TE 90 ms, TR 6.000 ms, matrix size 256×256, slice thickness 4 mm)

Methodology

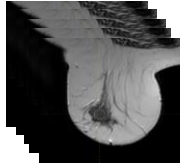| Multiparametric MRI	Manual 3D segmentation	Radiomic feature extraction	Statistical analysis

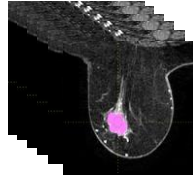**Multiparametric MRI**
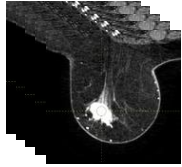
2nd post-contrast DCE
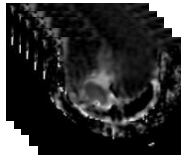
Apparent Diffusion Coefficient (ADC)

T2-FSE

Manual 3D segmentation

Radiomic feature extraction

- 3D Shape

- Grey-level Intensity Histogram

- Grey-level Co-occurrence Matrix

- Grey-level Run-Length Matrix

- Neighborhood Grey-level Difference Matrix

- Grey-level Zone Length Matrix

Statistical analysis

Feature selection:

- Wilcoxon test (a=5%)

- Logistic Regression with Elastic-net Regularization (a=0.75) and 10-fold cross-validation

Classification:

- Logistic Regression with 10-fold cross-validation

- ROC Analysis

C Nioche, F Orlhac, S Boughdad, S Reuzé, J Goya-Outi, C Robert, et al., LIFEx: a freeware for radiomic feature calculation in multimodality imaging to accelerate advances in the characterization of tumor heterogeneity. Cancer Research 2018; 78(16):4786-4789

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Results
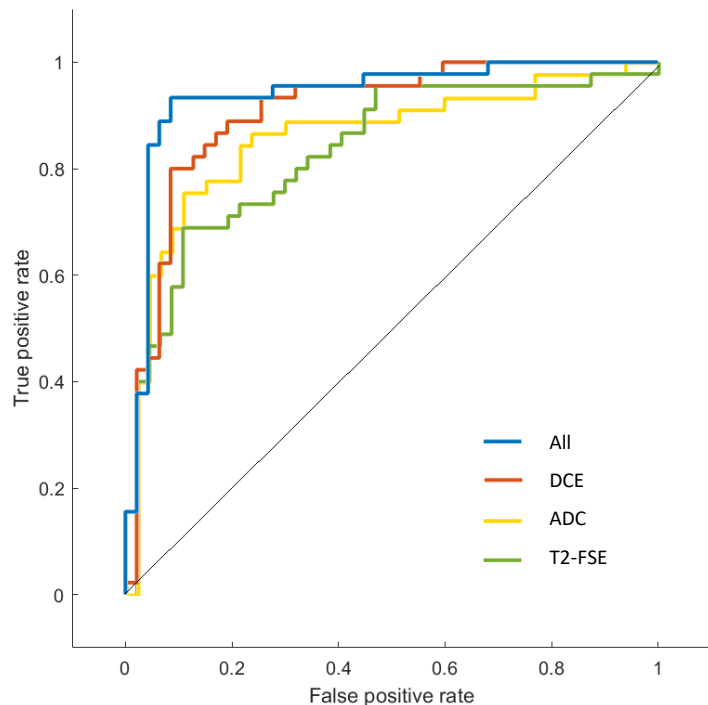
- 100 out of 138 radiomic features were identified as statistically significant (p<0.05) and used for classification modelling

	Number of features	AUC	Sensitivity	Specificity
All	7	0.94	0.89	0.94
DCE	4	0.91	0.82	0.85
ADC	3	0.86	0.78	0.79
T2-FSE	3	0.83	0.71	0.79

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Results

Table 1. Selected feature subsets for individual and multiparametric sequence analysis

	DCE (AUC = 0.91)	ADC (AUC = 0.86)	T2-FSE (AUC = 0.83)	mpMRI (AUC = 0.94)
SHAPE	COMPACITY	-	COMPACITY	DCE_COMPACITY
HISTOGRAM	MEDIAN SKEWNESS	MINIMUM QUARTILE_1 MEDIAN	ENTROPY (log_2)	DCE_MEDIAN DCE_SKEWNESS ADC_MINIMUM ADC_MEDIAN T2_ENTROPY (log_2)
TEXTURE	NGLDM_COARSENESS	-	NGLDM_COARSENESS	DCE_NGLDM_COARSENESS

- Multiparametric model comprised of features from all MRI sequences and feature extraction methods

- ADC feature subset comprised of histogram features

- DCE and T2-FSE feature subsets were highly correlated

Results

Table 2. Selected feature subsets for multiparametric evaluation

	mpMRI with shape features (AUC = 0.94)	mpMRI without shape features (AUC = 0.94)
SHAPE	COMPACITY	n/a
HISTOGRAM	DCE_MEDIAN DCE_SKEWNESS ADC_MINIMUM ADC_MEDIAN T2_ENTROPY (log2)	DCE_MEDIAN DCE_SKEWNESS ADC_MINIMUM ADC_MEDIAN T2_ENTROPY (log2)
TEXTURE	DCE_NGLDM_COARSENESS	DCE_NGLDM_COARSENESS DCE_GLZLM_ZLNU T2_NGLDM_CONTRAST

- Textural features were highly correlated with shape features

Limitations

- Small training-testing dataset

- Lack of an external validation dataset

- Only one classification algorithm was used

Conclusion

- Integration of all the available sequences of an advanced MRI protocol in radiomic models could improve the classification performance for differentiating benign and malignant lesions

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