Associations of breast MR derived vascular, shape and texture parameters with histological prognostic indicators

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Introduction A number of authors have investigated associations between MR vascular parameters and traditional histopathological prognostic markers. Results have varied with some studies revealing correlations[(1-4)] while others have failed to find any associations[(5-6)]. The aim of this work was to determine if there were any associations not only between pre-treatment MR derived vascular parameters and histopathological prognostic markers but also between MR determined shape and texture parameters with traditional prognostic indicators obtained from pre-treatment biopsies.

Methods Patients were scanned on a 3.0T HDx scanner (GE Healthcare). In each case a 3D dynamic dataset was acquired utilising VIBRANT. Shape, texture and model free vascular kinetics (empirical) parameters were acquired. Semi-automated ROI's were generated on each slice that demonstrated malignant tissue throughout the breast from an early arterial phase. Texture and shape analysis were undertaken purely from this early arterial phase. For the texture analysis multiple 2D datasets were averaged to provide a pseudo 3D analysis. This averaging approach was felt to be unsuitable for shape analysis, consequently, a 2D approach was adopted whereby only the ROI with the largest cross sectional area was interrogated. For kinetic analysis the signal intensities from the individual ROI's were averaged for each individual temporal phase prior to analysis. Traditional histopathological prognostic markers were dichotomised as follows; Grade (III or all others), HER2 (-ve or +ve), oestrogen receptor (ER) (-ve or +ve), progesterone receptor (PR) (-ve or +ve), ER and PR (ER & PR -ve or all others), ER, PR and HER2 receptor (ER, PR & HER2 –ve or all others) and sentinel node biopsy (SNB) (-ve or +ve). Initially simple univariate t-tests were employed to demonstrate any significant differences. However, since 33 different MR parameters (16 texture, 13 vascular, 4 shape) were generated principle component analysis (PCA) was undertaken as a means of data reduction. The resulting principle components were then entered into a logistic regression analysis (LRA) model for each prognostic marker.

Results Histopathological results were available in ninety-six patients, however, not all results were available in all patients, notably SNB which was not undertaken in every case. Univariate t-tests revealed a close association between vascular parameters and HER2 status. However, texture parameters demonstrated a greater association with ER, PR, grade and nodal status. Shape failed to demonstrate any significantly differences, see Table I. While the univariate results are encouraging this technique does not take into account correlations and interaction between the variables studied.

Parameter	Grade	HER2	ER	PR	ER&PR	ER,PR&HER2	SNB
Rise time	0.016	<0.001	0.011	0.017	0.011		
MITR		<0.001					
nMITR		<0.001					
EI@30sec		0.035					
PC@30sec	0.018	0.006			0.049		
Initial slope		0.035					
Final slope							0.043
AUC@30sec		0.040					
AUC@60sec		0.045					
f3			0.025	0.028			
f4	0.017		0.002	0.002	0.002	0.008	0.030
f5			0.017		0.017		
f6	<0.001		<0.001	<0.001	<0.001	<0.001	0.002
f7	0.008		<0.001	<0.001	<0.001	<0.001	0.011
f8	0.006		<0.001	<0.001	<0.001	0.001	0.046
f15	0.032		<0.001	<0.001	<0.001	<0.001	0.002
f16	0.010		<0.001	<0.001	<0.001	0.001	0.008

Table I. p values between the dichotomised prognostic groups for each significant MR parameter

PCA revealed that the first two components accounted for at least 86.4% of the variability of the data in vascular (86.4%), texture (86.8%) and shape (86.4%) parameters. Consequently, for each group (vascular, texture and shape) only the first two components were entered into the LRA model. Table II reveals the parameters retained by the LRA model for each histopathological prognostic indicator.

Prognostic indictor	Dichotomy and N	Parameter retained by LRA model
Grade	I or II 38, III 55	Texture 1, texture 2
HER2	-ve 73, +ve 17	Vascular 1, vascular 2, shape 1
Oestrogen	-ve 29, +ve 67	Vascular 1, texture 1, texture 2, shape 2
Progesterone	-ve 44, +ve 52	Vascular 1, texture 1, texture 2, shape 2
ER and PR	ER&PR –ve 29, all others 67	Vascular 1, texture 1, texture 2, shape 2
ER, PR and HER2	Triple –ve 23, all others 67	Texture 1, texture 2, shape 2
SNB	-ve 11, +ve 35	Texture 2

Table II.

Conclusions This work provides limited support to the findings of previous investigations that have demonstrated significant associations between MR derived vascular kinetics and histopathological markers of prognosis. Additionally, this work has revealed significant associations between MR texture and shape parameters with traditional prognostic indicators. Moreover texture parameters were retained by the LRA model more often than both vascular and shape descriptors.

Future Work Follow this patient cohort to establish if pre-treatment MR parameters shape, texture and vascular kinetics provide a more useful insight into DFS and OS than traditional prognostic indicators.

References [1]Mussurakis S et al. Br J Radiol 1997 70:446-451, [2]Narisada H et al. AJR 2006 187:297-306, [3]Tuncbilek N et al. Eur J Radiol 2005 53:199-205, [4]Baltzer PAT et al Eur Radiol 2010 20:1563-1571, [5]Stomper PC et al. Radiology 1995 197:387-395, [6]Fischer U Eur Radiol 1997 7:1002-1005

Abbreviations EI enhancement index, PC percentage enhancement, MITR maximum intensity time ration, nMITR normalised MITR