

## Magnetic Resonance Imaging in Equivocal Breast Cytology: Does Quantitative Textural and Morphometric Analysis Have Added Value?

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**Synopsis:** Quantitative textural (co-occurrence matrix) and morphometric (cross-sectional area and shape) analyses were carried out upon static T<sub>1</sub>-weighted contrast-enhanced MRI images acquired in 38 cases of suspected breast cancer in which an equivocal cytology result had been obtained. It was found that the small increase in diagnostic power provided by the textural and morphometric parameters, over and above that provided by pharmacokinetic analysis of dynamic T<sub>1</sub>-weighted contrast-enhanced imaging carried out at the same time, was not statistically significant; suggesting that textural and morphometric analyses do not provide added value.

**Introduction:** It has previously been shown that in breast cancer patients with equivocal cytology, subsequent dynamic contrast-enhanced (DCE-) MRI is able to provide an accurate, unequivocal diagnosis in up to 50% of cases [1]; a fact which could obviate the need for additional surgical biopsy, with its associated physical and psychological trauma, in a substantial number of cases. The 50% of cases in which DCE-MRI was unable to provide a definite diagnosis included pathologies which are fundamentally difficult to diagnose by DCE-MRI alone (e.g. highly vascular, therefore rapidly enhancing, benign lesions). Quantitative texture analysis of static contrast-enhanced MRI has been shown to have diagnostic power in breast cancer [2] therefore a study was carried out to determine if such quantitative analysis could provide an increase in diagnostic efficacy in the equivocal cytology patient sub-set.

**Methods: Patients and MRI:** A retrospective study was carried out of all suspected breast cancer patients who had been referred, over a period of two years, for MRI subsequent to an equivocal breast cytology result (C3/C4). A total of 38 patients were identified, 14 of which had histologically proven malignancies. All images were acquired at 1.5 T (IGE Signa Advantage). Prior to contrast injection a series of proton density weighted fast spoiled grass (FSPGR) images were acquired (TR/TE/flip = 120 ms / 4.2 ms / 8 deg.) to enable subsequent correction for differences in native tissue T<sub>1</sub> [3]. DCE-MRI was carried out, following bolus injection of Gd-DTPA (0.1 mmol/kg body weight), using a T<sub>1</sub>-weighted FSPGR sequence (TR/TE/flip = 11.0 ms / 4.2 ms / 30 deg., temporal resolution = 11.6 s, 35 images at each slice location, 7 minute scan time). High resolution T<sub>1</sub>-weighted 3D, post-contrast, fat-suppressed FSPGR images were also acquired (TR/TE/flip = 27.9 ms / 4.2 ms / 30 deg., 28 sagittal slices, up to 5 mm thick, 24 cm FOV, 512 x 256 matrix).

**Image Analysis:** Regions-of-interest delimiting the lesions were drawn, by an experienced radiologist, on both the DCE-MRI and 3D images. The mean pixel signal intensity within each DCE-MRI ROI was calculated over time using software developed in-house and a three compartment pharmacokinetic (PK) model [4] was used to calculate microvessel transfer constant (K<sup>trans</sup>), exchange rate (K<sub>ep</sub>) and the extracellular-extravascular tissue volume fraction (V<sub>e</sub>). 3D images were decimated to 32 grey levels, to avoid data sparseness, then analysed using co-occurrence matrices to yield 14 textural parameters [2, 5]. Lesion cross-sectional area and circularity (coefficient of variation of radii from the centre-of-mass to each perimeter pixel) were also quantified. **Statistical Analysis:** Diagnostic efficacy was assessed using receiver-operator characteristic curves and the areas contained underneath them (AUC). Parameters were combined, in the hope of attaining a synergistic increase in diagnostic efficacy, using logistic regression analysis (LRA) modelling.

Parameter or LRA Model	ROC AUC	Spec. @ 100% PPV	Sens. @ 100% NPV	Unequiv. Diagnosis
<b>Cytology</b>	<b>0.87 *</b>	<b>0/24: 0%</b>	<b>0/14: 0%</b>	<b>0/38: 0%</b>
Mammography	0.71 *	0%	0%	0%
Age	0.63	4%	7%	5%
<b>MRM Grade</b>	<b>0.89 *</b>	<b>25%</b>	0%	<b>16%</b>
<b>PK: K<sub>ep</sub></b>	<b>0.91 *</b>	<b>46%</b>	<b>64%</b>	<b>42%</b>
Shape: area	0.60	33%	0%	21%
Texture: IDM	0.66	25%	0%	16%
<b>Cytol. / MRM</b>	<b>0.95 *</b>	25%	<b>50%</b>	<b>34%</b>
<b>Cytology / K<sup>trans</sup></b>	<b>0.95 *</b>	33%	<b>86%</b>	<b>53%</b>

**Results:** The AUC values for the three pre-MRI parameters (cytology grade, mammography grade and patient age) are presented in the table along with those for MRM grade (expert radiologist) and the most efficacious individual PK, morphometric and texture parameters (K<sub>ep</sub>, cross-sectional area and inverse difference moment, IDM, respectively). It can be seen that MRM grade and the 3 quantitative parameters have the advantage over pre-MRI data in that an accurate, unequivocal diagnosis (i.e. with 100% positive and/or 100% negative predictive value, PPV and NPV respectively) could be made in an appreciable

number of cases because benign and malignant data were sufficiently well separated. Results of LRA modelling indicated that whilst the inclusion of MRM grade and PK parameters led to a statistically significant increase in diagnostic power, over-and-above that obtainable with pre-MRI data only (see table), the inclusion of textural and morphometric parameters did not.

**Discussion:** It has been shown that PK analysis of DCE-MRI can provide an accurate, unequivocal diagnosis in approximately half of all C3/C4 cases. Given that the LRA model developed using PK parameters performed marginally better than the one developed using MRM grade, it should be possible to develop software which would permit rapid, semi-automated analysis of DCE-MRI which could have a useful role in second reading. Despite containing a small amount of diagnostic power in isolation, quantitative textural and morphometric parameters were not able to provide added value in the overall evaluation of C3/C4 cases by MRI / LRA modelling.

[1] D.J. Manton, *et al. Proc ISMRM* 7 abstr. 1079 (1999) [2] P. Gibbs, *et al. Proc. ISMRM* 10 abstr. 1910 (2002) [3] K. Hittmair, *et al. Magn. Reson. Med.* **31** (1994) [4] P. Tofts, *et al. Magn. Reson. Med.* **17** (1991) [5] R.M. Haralick *Proc. IEEE* **67** (1979)