MRI Texture Analysis For Preoperative Staging of Renal Cell Cancer

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Target Audience: Abdominal radiology, Image analysis

Introduction: The accurate preoperative staging of renal cell carcinoma (RCC) is important for assessing prognosis and planning therapy. Localized (or organ confined) RCCs, stage 1 and 2, have better prognosis and can be treated with curative surgery. More aggressive stage 3 and 4 RCCs, defined by extra-renal extension, have worse prognosis. Although stage 3 or 4 RCC are often treated with surgery, there is a very high rate of recurrence (1). Anatomic imaging is often limited in detecting capsular invasion, adjacent organ invasion, and metastasis in normal sized lymph nodes (2). It is commonly observed that higher stage renal cancers have internal necrosis and heterogeneity (**Figure 1**), and thus it may be possible that these tumors have different texture characteristics compared to lower stage RCC. Magnetic resonance imaging (MRI) texture analysis has been used in previous investigations to distinguish benign from malignant breast masses and lymph nodes (3, 4), but not to assess RCC aggressiveness.

Purpose: To assess the utility of texture measures on structural and diffusion-weighted MRI in differentiating low stage (1 & 2) from higher stage (3 & 4) RCCs.

Methods: 65 patients (41 men, 24 females, mean age 64±14 years) underwent resection of solid renal mass at our large academic medical center between January 2011 and January 2012 and had 1.5 T renal MRI performed prior to surgery. Our standard MRI protocol included diffusion weighted imaging with b-value of 0 and 800 sec/mm^2, and T1 weighted fat-saturated gradient echo (VIBE) imaging in corticomedullary (CM) phases of enhancement after contrast administration. A radiologist assessed tumor signal characteristics and drew volumes of interests (VOIs) on every slice that included the mass on the ADC map as well as the CM phase. Lesion texture measures were computed using Mazda version 4 (Technical University of Lodz, Poland [5]). Fisher coefficient (F) and classification error probability (POE) combined with average correlation coefficients (ACC) were used to identify 10 texture features which best discriminate between RCCs of high and low stage. These features were analyzed by nonlinear discriminant analysis (NDA) and principal component analysis (PCA).

Table 1	**Percentage**	
MR features	S1 & 2	S3 & 4
T1 signal		
Isointense	9/29 (31%)	13/36 (36%)
Hypointense	18/29 (62%)	19/36 (52%)
Hyperintense	2/29 (7%)	4/36 (11%)
T2 signal		
Isointense	3/29 (10%)	7/36 (19%)
Hypointense	8/29 (27%)	8/36 (22%)
Hyperintense	18/29 (62%)	21/36 (58%)
T1-W +C		
Homogeneous	5/29 (17%)	1/36 (3%)
Heterogeneous	25/29 (86%)	35/36 (97%)

Results and Discussion: At histopathology, 29 lesions were stage 1 and 2 (21 clear cell, 8 papillary) and 36 lesions were stage 3 and 4 (31 clear cell, 2 papillary, 3 chromophobes). Stage 3 and 4 lesions were significantly greater in size than stage 1 and 2 (7.4 vs. 3.6 cm, $p < 0.05$). There were no significant difference in T1 and T2 signal, or enhancement parameters (**Table 1**), however, there were differences in texture signatures between the low and high stage tumors (**Table 2**). The textural differences in ADC correctly discriminated 92% of these tumors (using NDA analysis). 91% of lesions were also correctly classified as low or high stage on texture analysis of CM post-contrast T1-weighted image. The measures with strongest discriminating power were second-order textures. For ADC they were mostly derived from in-plane co-occurrence matrix..For T1-W images, the best measures were derived from the directional (vertical, horizontal and diagonal) run-length matrix.

Feature Selection	**Fisher**	**POE**
ADC Map		
PCA	48/65 (74%)	48/65 (74%)
NDA	60/65 (92%)	59/65 (91%)
T1-W+C (CM)		
PCA	43/65 (66%)	47/65 (72%)
NDA	56/65 (86%)	59/65 (91%)

Table 2:. Classification of low and high stage RCC.

Conclusions: Conventional MR Imaging did not demonstrate significant differences between low and high stage RCC. However, lesion size and texture features on ADC and post-contrast CM phase images were significantly different between low and high stage RCCs in our large cohort. Sampling of the entire lesion allowed for unbiased measurement of texture parameters. Future work is needed to prospectively validate our size+texture model on an independent cohort to non-invasively predict preoperative RCC stage.

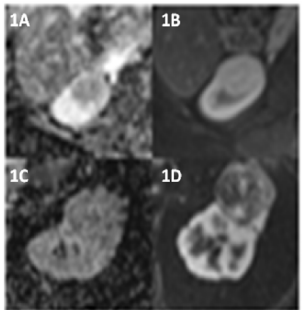

Figure 1: Stage 1 RCC (A) ADC map and (B) post contrast CM phase demonstrates homogeneous appearance compared to stage 4 RCC (C) ADC map and (D) CM phase acquisition.

References: [1] Mickisch GH, et al. Lancet 2001;358:966-70 [2] Ergen FB, et al. AJR 2004;182:217–225 [3] Holli K, et al. Acad Radio; 2010;17:135-41 [4] Harrison LC, et al. Exp Clin Cancer Res 2009; [5] Szczypinski PM, et al. Comput Methods Programs Biomed 2009;94:66-76