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EVALUATION OF CLINICAL VARIABLES, RADIOLOGICAL VISUAL ANALOG SCORING, AND RADIOMICS FEATURES ON MR ENTEROGRAPHY FOR CHARACTERIZING SEVERE INFLAMMATION AND FIBROSIS IN STRICTURING CROHN'S DISEASE



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BACKGROUND

- MR enterography (MRE) offers excellent diagnostic accuracy of Crohn's disease (CD) strictures, but cannot accurately determine the extent of stricture fibrosis and inflammation.
- Radiomics, a quantitative image extraction analysis technology, may offer a solution.
- We present initial results for a machine-reader evaluation of severe inflammation and fibrosis in CD strictures via quantitative radiomic features and expert radiologist scoring of MRE.

METHODS

- Retrospective, single center, IRB-approved study.
- 51 patients (n=34 for discovery; n=17 for hold-out validation) had confirmed stricturing CD on MRE and histopathology from surgery within 15 weeks of MRE.
- Histopathological Stenosis Therapy & Research (STAR) scoring of specimens (range 0-100, scores ≥ 50 =severe) was the reference standard for both inflammation and fibrosis.
- An expert radiologist coordinated with the scoring pathologist to annotate the resected strictures on MRE and provide a global visual analog score (VAS, 0-100) assessment of inflammation and chronic non-inflammatory findings (fibrosis).
- 1852 3D radiomic features were extracted from the stricture regions on MRE, from which the most relevant feature subsets were identified via cross-validated machine learning analysis in the discovery cohort for differentiating between severe vs less severe inflammation and fibrosis.
- Radiomic features and VAS scores were evaluated against pathology-defined severe inflammation and fibrosis in the validation cohort via ROC analysis.

Table 1: Demographics and baseline clinical features of the cohort, segregating discovery and hold-out validation radiomic cohort.

Factor	MRE Overall (N=51)		Fibrosis Discovery Group (N=34)		Fibrosis Validation Group (N=17)		P-value	Inflammation Discovery Group (N=34)		Inflammation Validation Group (N=17)		P-value
	N	Statistics	N	Statistics	N	Statistics		N	Statistics	N	Statistics	
Male Sex, n (%)	51	26 (51)	34	16 (47)	17	10 (57)	0.43 ^a	34	15 (44)	17	11 (65)	0.17 ^a
Diagnosis age of IBD, median (range), yrs	51	21 (4-90)	34	24 (10-90)	17	20 (2-62)	0.88 ^c	34	20.5 (5-67)	17	25 (4-90)	0.79 ^c
Diagnosis age of Stricture, median (range), yrs	51	32 (11-90)	34	30.5 (19-90)	17	33 (11-69)	0.78 ^c	34	29.5 (11-71)	17	35 (20-90)	0.24 ^c
Age at MRE, median (range), yrs	51	34 (18-91)	34	33 (19-91)	17	36 (18-69)	0.83 ^c	34	31 (18-71)	17	37 (22-91)	0.21 ^c
Duration between IBD/stricture dx, median (range), years	51	8 (0-30)	34	6.5 (0-30)	17	10 (0-26)	0.62 ^c	34	7.5 (0-30)	17	8 (0-21)	0.8 ^c
Duration between Stricture dx/Surgery, median (range), months	51	9 (0-145)	51	10 (0-145)	17	6 (0-121)	0.82 ^c	34	5.5 (0-145)	17	19 (0-78)	0.24 ^c
Duration between MRE and resection, median (range), weeks	51	7.1 (0-15)	34	7.35 (0-13)	17	7 (0.9-15)	0.36 ^c	34	7.9 (0.1-15)	17	7.1 (0-14.9)	0.93 ^c
Obstructive Symptoms at time of imaging, n (%)	51	42 (82)	34	28 (82)	17	14 (82)	1 ^b	34	27 (79)	17	15 (88)	0.7 ^b
CD Montreal Classification, n (%)	51		34		17		0.64 ^a	34		17		0.14 ^a
B2 (Stricturing)		23 (45)		14 (41)		9 (53)			17 (50)		6 (35)	
B2p (Stricturing with perianal disease)		15 (29)		11 (32)		4 (23)			11 (32)		4 (23)	
B3 (Fistulizing)		6 (12)		5 (15)		1 (6)			4 (12)		2 (12)	
B3p (Fistulizing with perianal disease)		7 (14)		4 (12)		3 (18)			2 (6)		5 (29)	
History of extraintestinal manifestations, n (%)	51	32 (63)	34	22 (65)	17	10 (59)	0.68 ^a	34	22 (65)	17	10 (59)	0.68 ^a
Ileocecal resection prior to current stricture, n (%)	51	25 (49)	34	17 (50)	17	8 (47)	0.84 ^a	34	16 (47)	17	9 (53)	0.69 ^a
Number of resections, median (range)	25	2 (1-5)	16	2 (1-5)	8	2 (1-4)	0.88 ^c	16	2 (1-4)	8	2 (1-5)	0.94 ^c
Type of stricture, n (%)	51		34		17		1 ^a	34		17		1 ^a
Naive		27 (53)		18 (53)		9 (53)			18 (53)		9 (53)	
Anastomotic		24 (47)		16 (47)		8 (47)			16 (47)		8 (47)	
Medications for IBD <8 weeks from imaging, n (%)	51		34		17			34		17		
5-aminosalicylic-acid, oral or rectal		10 (20)		8 (24)		2 (12)	0.46 ^b		6 (18)		4 (24)	0.71 ^b
Steroid, systemic		19 (37)		11 (32)		8 (47)	0.31 ^a		12 (35)		7 (41)	0.68 ^a
Steroid, rectal or Budesonide		12 (24)		9 (27)		3 (18)	0.73 ^b		8 (24)		4 (24)	1 ^b
Mercaptopurine or Azathioprine		12 (24)		7 (21)		5 (29)	0.5 ^b		10 (29)		2 (12)	0.29 ^b
Methotrexate		2 (4)		2 (6)		0 (0)	0.55 ^b		1 (3)		1 (6)	1 ^b
Certolizumab		2 (4)		2 (6)		0 (0)	0.55 ^b		1 (3)		1 (6)	1 ^b
Adalimumab		13 (25)		10 (29)		3 (18)	0.5 ^b		8 (24)		5 (29)	0.74 ^b
Infliximab		5 (10)		3 (9)		2 (12)	1 ^b		4 (12)		1 (6)	0.65 ^b
Vedolizumab		5 (10)		4 (12)		1 (6)	0.65 ^b		2 (6)		3 (18)	0.32 ^b
None		6 (12)		4 (12)		1 (6)	0.65 ^b		4 (12)		1 (6)	0.65 ^b
Global Assessments by Radiologist												
Global Stricture Severity, median (range), 0-100	51	60 (20-100)	34	50 (20-100)	17	60 (20-100)	0.4 ^c	34	60 (20-100)	17	40 (20-95)	0.44 ^c
Global Inflammation Severity, median (range), 0-100	51	40 (15-95)	34	40 (15-85)	17	50 (15-95)	0.27 ^c	34	40 (15-85)	17	40 (15-95)	0.7 ^c
Global Chronic non-inflammatory changes Severity, median (range), 0-100	51	30 (5-80)	34	30 (5-80)	17	40 (5-80)	0.16 ^c	34	30 (5-80)	17	30 (5-70)	0.89 ^c
Global Assessments by Pathologist												
Severity of inflammation, median (range), 0-100	51	66 (2-100)	34	67 (2-100)	17	64 (10-94)	0.52 ^c	34	61.5 (2-100)	17	67 (10-100)	0.73 ^c
Severity of fibrosis, median (range), 0-100	51	60 (5-94)	34	60 (5-94)	17	55 (10-88)	0.93 ^c	34	57.5 (5-94)	17	63 (10-90)	0.93 ^c

a= Chi-Square test b=Fisher exact test, c= Mann Whitney U test. MRE: magnetic resonance enterography; N: Number; IBD: inflammatory bowel disease; dx: diagnosis; CD: Crohn's disease.

RESULTS

- Two distinct sets of radiomic features capturing textural heterogeneity (patterns, local entropy) within strictures were significantly associated (p<0.01) with severe inflammation and severe fibrosis; across both discovery (AUC=0.66, 0.76) and hold-out validation (AUCs =0.71,0.83).
- Radiological VAS had AUC=0.68/0.47 for identifying severe inflammation/severe fibrosis. Combined radiomic features and VAS had no significant impact on predictor performance.
- Clinical variables including sex, age, Montreal classification and stricture type were not associated with severe inflammation or fibrosis, across discovery and validation groups.

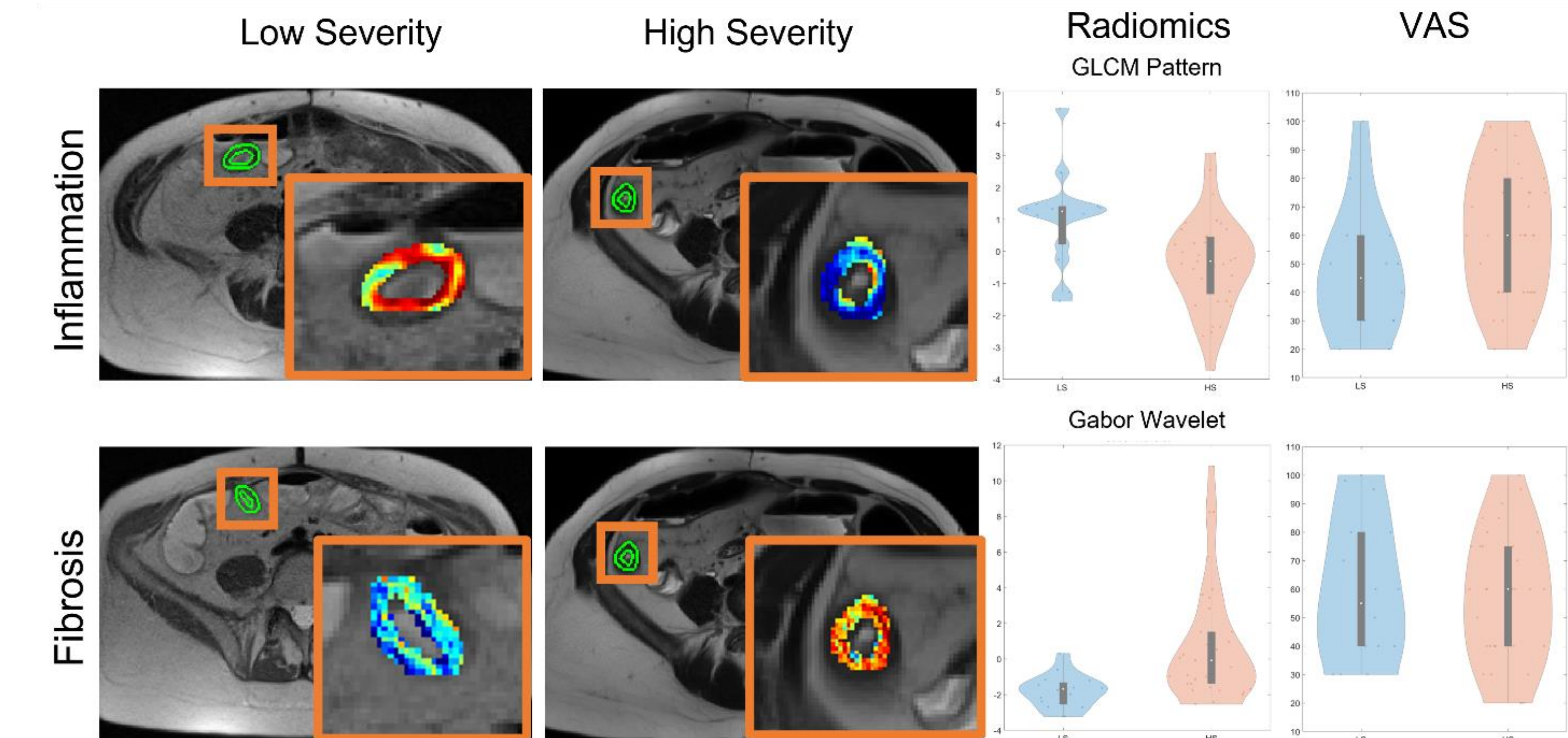


Figure 1: Top-ranked radiomics features distinctively associated with severe inflammation (top row, pattern-based) and severe fibrosis (bottom row, wavelets) on MRE. Also shown are radiological VAS for severe inflammation and severe fibrosis.

CONCLUSIONS

- Radiomic analysis shows improved performance in identifying severe inflammation and severe fibrosis in CD strictures on MRE compared to radiological visual assessment scoring and clinical variables.