Automated Fibrosis Phenotyping of NASH non-tumorous lesions digital images helps classify HCC and non-HCC NASH patients who underwent liver transplantation

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BACKGROUND

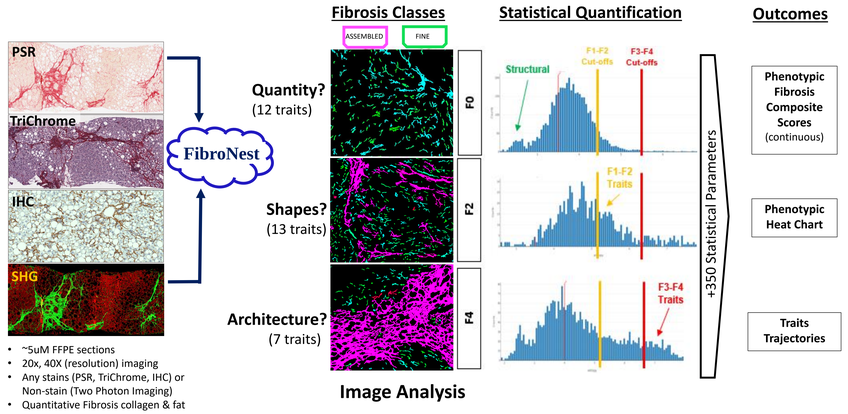
The incidence of Hepatocellular carcinoma (HCC) arising from NAFLD has been increasing worldwide.

Advanced liver fibrosis, especially liver cirrhosis, is a risk factor for HCC development in NASH/NAFLD. However, it is not known whether there is a distinct fibrosis histological pattern (or phenotype) that is related to development of HCC in patients with liver cirrhosis.

In this this study, we evaluated the performance of analysis of fibrosis histological phenotypic features **to identify traits that differentiate HCC and non-HCC primary liver malignancy in NASH liver cirrhosis patients** who underwent liver transplantation.

METHOD

TISSUE PREPARATION, INSTRUMENTATION, AND WORKFLOW



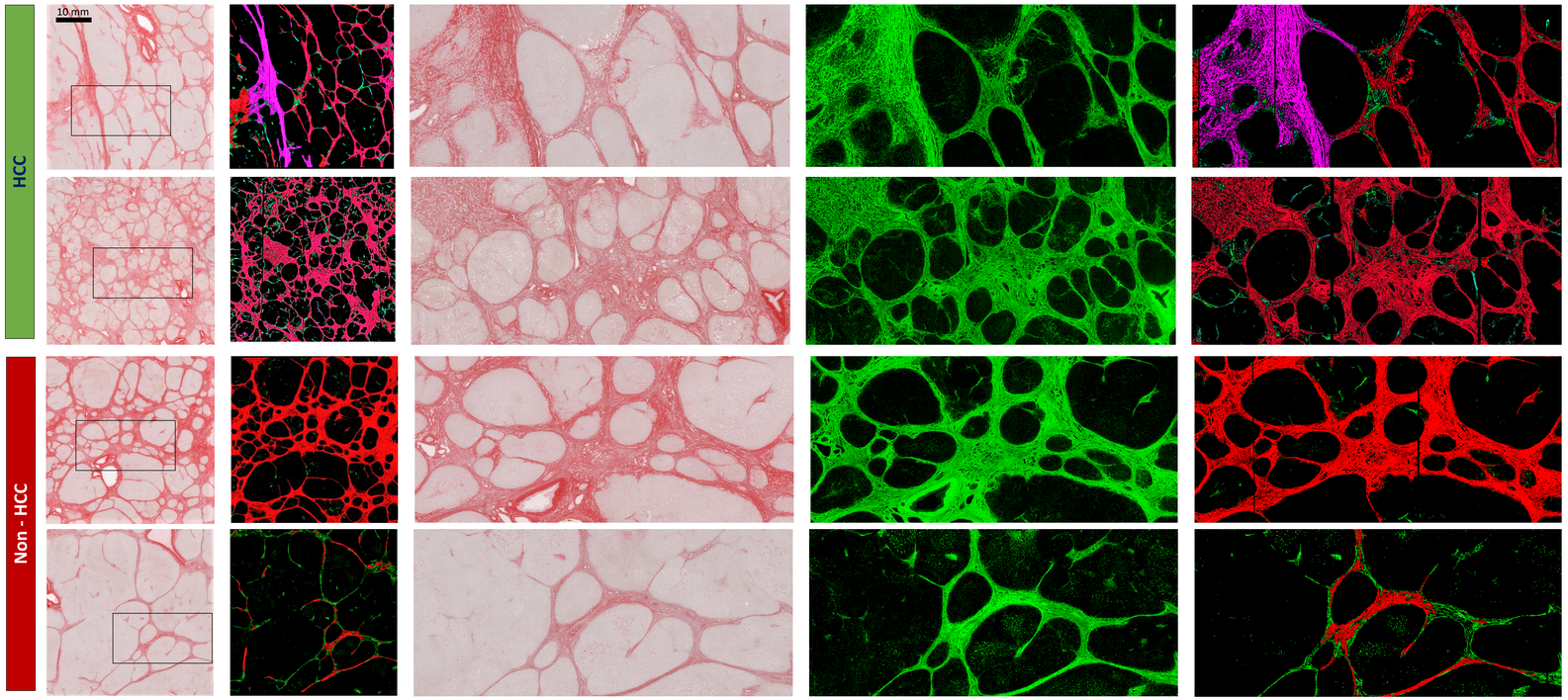
- ~5uM FFPE sections
- 20x, 40X (resolution) imaging
- Any stains (PSR, TriChrome, IHC) or Non-stain (Two Photon Imaging)
- Quantitative Fibrosis collagen & fat

Group	Description	Gold Standard	Total N 17
HHC+	NASH patients who underwent liver transplantation with a NASH CRN Fibrosis Score of F4 and HCC diagnostic	Histologic assessment was assessed by pathologists	N= 8
HCC-	NASH patients who underwent liver transplantation with a NASH CRN Fibrosis Score of F4 and negative HCC diagnostic		N=9

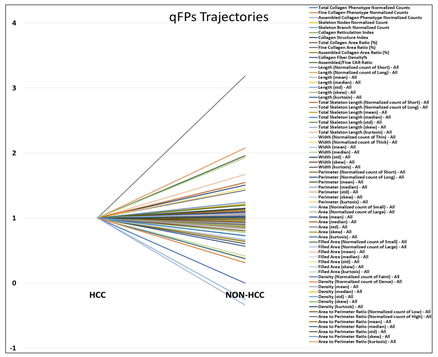
- FFPE sections (3-4 microns) of patient liver non-tumorous tissue were deparaffinized, stained for with Picro Sirus Red (no Hematoxylin bath) for Collagen and digitized at 40X (Aperio AT2)
- Using FibroNest™ the fibrosis phenotype is described for its collagen content and structure (12 traits), the morphometric traits of the collagen fibers (13 traits), and fibrosis architecture / texture traits (7). In each image, each morphometric and texture trait is represented by a histogram distribution (e.g. Fiber Skeleton Length histogram).
- The histogram for each trait is described by up to seven quantitative fibrosis parameters (qFPs, 315 in total) to account for mean, variance, distortion and progression.
- Principal qFPs are automatically detected if their group distribution (N=8 or N=9) significantly different ($p<0.001$, T- TEST), and normalized group mean value ratio greater than 1.2
- Principal qFPS are used individually and collectively to describe the differences in phenotypes between the two groups. They ate combined into a normalized Phenotypic Composite Fibrosis Score (Ph-CFS), a continuous quantifier of the HCC fibrosis phenotype.
- Cut-off values are selected to optimize the performance of a test to classify the patients (HCC or non-HCC) based on their Ph-CFS. The performance of the test is evaluated using a confusion matrix and its related sensitivity and specificity values.

RESULTS

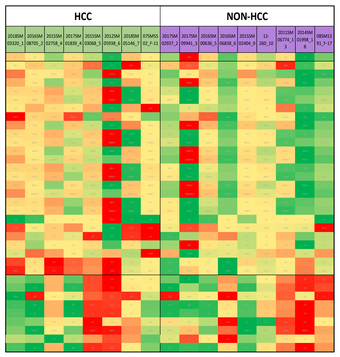
REPRESENTATIVE IMAGES AND FIBRONEST ANALYSES



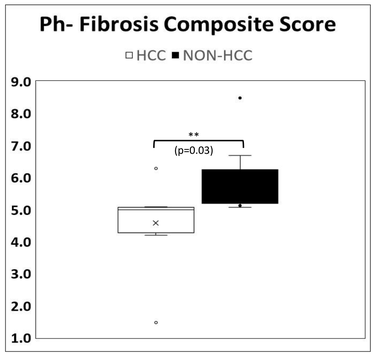
PHENOTYPIC QUANTIFICATION



qFP trajectories (normalized to HCC phenotype) describe the differences between HCC and non-HCC Phenotypes and highlight principal qFPs



Phenotypic Heat charts describe each Patient's phenotype (principal qFPs only)



The Phenotypic Composite score is assembled from Principal qFPs and helps classify the HCC and non-HCC Patients

HCC+ PHENOTYPIC TEST (POC, N=17)

			TRUE CONDITION			
			Mehod Definition: Pathologist			
			HCC+	HCC-	Prevalence	Accuracy (ACC)
	Cut Off Ph-FCS=5	17	8	9	47.06%	88.24%
PREDICTED CONDITION	HCC+ (Ph-FCS < 5.0)	6	True Positive (Power) 6	False Positive 0	Positive Predictive Value (PPV) or Precision 100.00%	False Discovery Rate (FDR) 0.00%
	HCC- (Ph- FCS >= 5.0)	11	*False Negative* 2	*True Negative* 9	*False Omission Rate (FOR)* 18.18%	*Negative Predictive Value (NPV)* 81.82%
			True Positive Rate (TPR) or Recall, Sensitivity, 75%	False Positive Rate (FPR) or Fall-Out or Probability 0.00%	Positive Likelihood Ratio (LR+)	Diagnostic Odd Ratio (DOR=LR+/LR-
			False Negative Rate (FNR) or Miss Rate 25.00%	***Specifity (SPC) Selectivity or True Negative Rate (TNR)*** **100%**	Negative Likelihood Ratio (LR-) 0.25	

100% Sensitivity and 100% Specificity (N=17)

Conclusion

Fibrosis histological phenotypic quantification helps to distinguish between HCC and non-HCC in NASH liver cirrhosis patients who underwent liver transplant. These data show that phenotypic analysis of collagen with FibroNest™ is an effective and automated method to classify HCC from non-HCC in histopathology imaging studies. This can be of clinical importance for appropriate guidance of treatment strategy