Smart Atlas for Supporting the Interpretation of probe-based Confocal Laser Endomicroscopy (pCLE) of Gastric Lesions: First Classification Results of a Computer-Aided Diagnosis Software based on Image Recognition

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BACKGROUND AND AIMS:
pCLE enables microscopic imaging of gastrointestinal mucosal lesions, *in vivo* and in real time, during an endoscopy procedure. Recent studies have demonstrated that pCLE enables accurate diagnosis of superficial gastric neoplasia. In parallel, a computer-aided diagnosis software called Smart Atlas has been developed to assist endoscopists with the interpretation of pCLE sequences. This study aims at evaluating the performance of this software for the classification of gastric lesions into four pathological classes: healthy stomach, gastric intestinal metaplasia (GIM), dysplasia, and cancer.

METHODS:
Several pCLE video sequences were retrospectively collected from pCLE procedures performed in multiple clinical centers. These sequences, along with their annotated final diagnosis, were used to train a classification software that uses a content-based image retrieval algorithm to predict the diagnosis of a query video based on the diagnoses of the most visually similar atlas videos. For all cases, final diagnosis was based on histological analysis of corresponding tissue sampling. All evaluations were performed using leave-one-patient-out cross-validation to avoid bias. A confusion matrix was established to evaluate 4-class classification, and a receiver operating curve was generated to evaluate the binary classification between non-neoplasia (healthy stomach, GIM) and neoplasia (dysplasia, cancer).
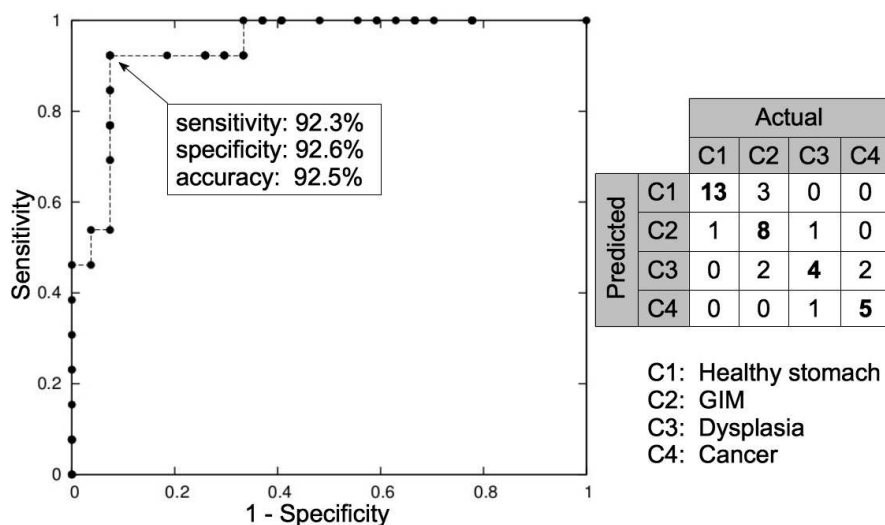
RESULTS:
Among the 40 pCLE video sequences collected from 30 patients, 14 were annotated with healthy stomach, 13 with GIM, 6 with dysplasia, and 7 with cancer. For the differentiation of non-neoplasia and neoplasia, the results maximizing the accuracy show an accuracy of 92.5%, a sensitivity of 92.3%, a specificity of 92.6%, a PPV of 85.7% and a NPV of 96.2%. The 4-class classification results show an average accuracy of 75% and per-class accuracies of 90% for healthy stomach, 82.5% for gastric intestinal metaplasia, 85% for dysplasia and 92.5% for cancer. In comparison, Bok at al. reported in GIE 2013 that, for real-time *in vivo* pCLE diagnosis of superficial gastric neoplasia, endoscopists achieve overall accuracy, sensitivity and specificity of 90.7%, 90.6% and 90.9%, respectively.

LIMITATIONS:
Small and unbalanced sample size.

CONCLUSIONS:
These first results demonstrate that gastric lesions can be automatically classified into four pathological classes by the Smart Atlas software based on the image content of pCLE video sequences only. The high accuracy, sensitivity and specificity results achieved by the software for differentiating non-neoplasia and neoplasia are comparable to those achieved by endoscopists. The case-based reasoning software could thus be used as an educational tool to train non-expert endoscopists, but also as a second-reader tool to assist any endoscopist in real-time diagnosis of gastric diseases using pCLE.

		Actual			
		C1	C2	C3	C4
Predicted	C1	**13**	3	0	0
	C2	1	**8**	1	0
	C3	0	2	**4**	2
	C4	0	0	1	**5**

C1: Healthy stomach
C2: GIM
C3: Dysplasia
C4: Cancer

sensitivity: 92.3%
specificity: 92.6%
accuracy: 92.5%

Left: Receiver operating characteristic curve for the binary classification between non-neoplastic and neoplastic gastric lesions. Right: Confusion matrix for further classification into 4 pathological classes.
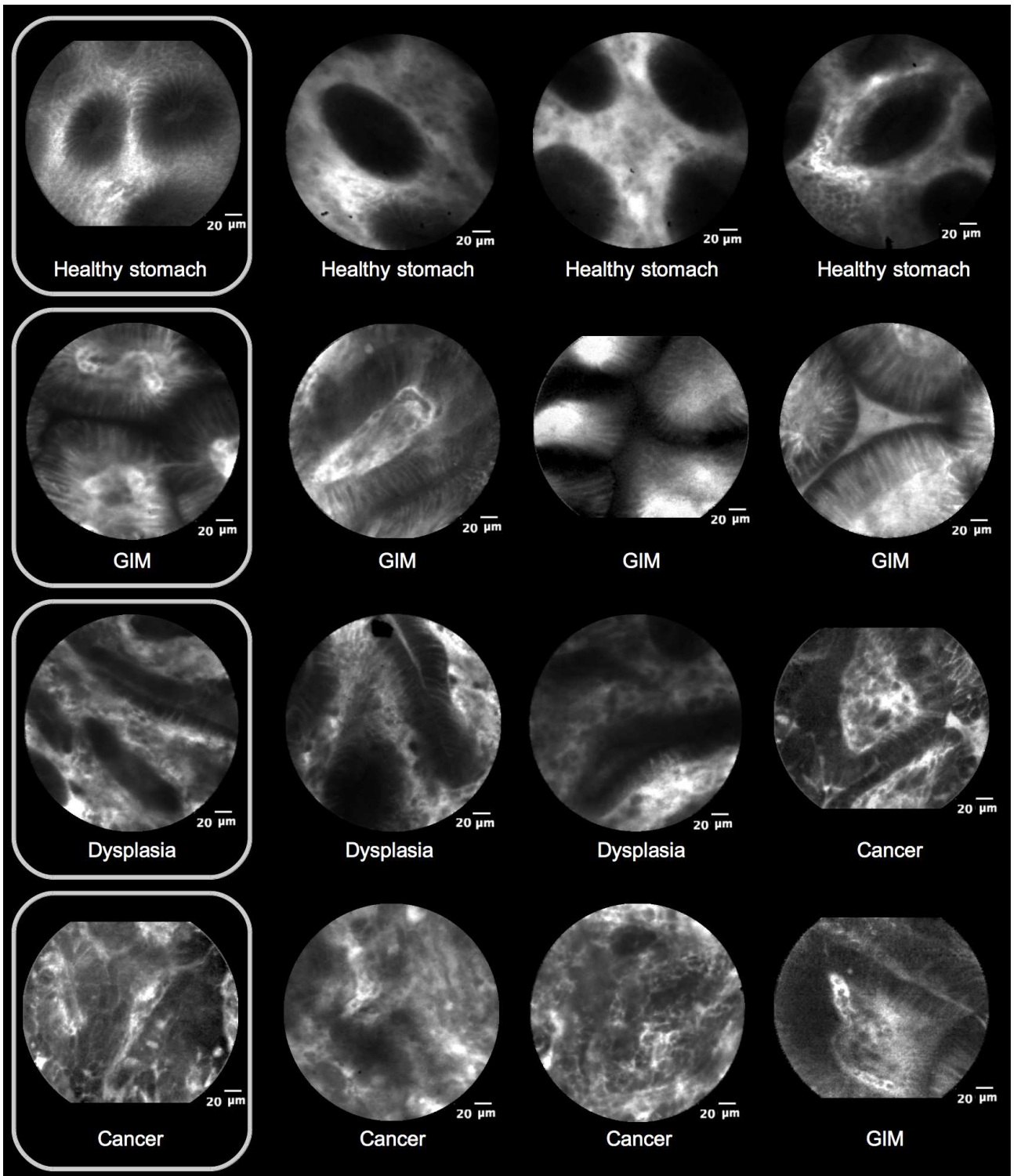
On each line: pCLE image representative of a query video (framed image on the left), followed by 3 pCLE images representative of the 3 atlas videos which have been automatically recognized by the Smart Atlas software as the most visually similar to the query video. Each pCLE video is annotated with final diagnosis.