

# P0334 Performance Testing of a Smartphone-based Patient Monitoring System measuring Calprotectin: Laboratory vs Lay Users

J. Weber<sup>1</sup>, P. Spies<sup>2</sup>, M.-E. Ueberschlag<sup>1</sup>, C. Reinhard<sup>1</sup>, S. Kräuchi<sup>1</sup>, Th. Jermann<sup>1</sup>



<sup>1</sup>BÜHLMANN Laboratories AG, Schoenenbuch, Switzerland

<sup>2</sup>University of Applied Life Sciences, Muttenz, Switzerland



University of Applied Sciences and Arts Northwestern Switzerland  
School of Life Sciences

## BACKGROUND & OBJECTIVE

Inflammatory Bowel Disease (IBD) is a chronic inflammation of the gut comprising active inflammation, remission and flares. The disease course can be followed by biomarkers such as calprotectin which is measured in patients' stool samples. Most studies have shown that a threshold around 250 µg/g correlates well with mucosal healing. Hence, one of the therapy goals is to achieve calprotectin values below 250 µg/g and to keep them below this level. We have developed a system, called *IBDoc*<sup>®</sup>, which allows the patient to regularly perform calprotectin tests at home and to check whether the low calprotectin level is under control (Fig. 1A). The objective of this study was to validate the *IBDoc*<sup>®</sup> home testing system by lay users vs. professional laboratory personnel and to compare its quantitative performance with routine laboratory-based methods.

## METHODS

Twenty-six stool samples containing various levels of calprotectin (18-2220 µg/g as per *fCAL*<sup>™</sup> ELISA), kindly provided by a local routine clinical laboratory, were extracted with the *CALEX*<sup>®</sup> Valve device by 31 lay users and two laboratory professionals. The stool extracts were then either loaded by the lay users and professionals onto immunochromatographic test cassettes (TCs) or analyzed with the commercial BÜHLMANN *fCAL*<sup>™</sup> ELISA test by the professional users. The lay users read the TCs via the *CalApp*<sup>®</sup> installed on 11 different models of iPhones and Android phones, whereas the professional users measured the TCs with their smartphone and the BÜHLMANN Quantum Blue<sup>®</sup> lateral flow test reader. Quantitative and qualitative agreements between lay users and professionals as well as quantitative performance of *IBDoc*<sup>®</sup> versus routine laboratory methods (eg. *fCAL*<sup>™</sup> ELISA) were assessed by Analyse-it for Microsoft<sup>®</sup> Excel.

## RESULTS

### Quantitative result and its presentation by a traffic-light system

The *IBDoc*<sup>®</sup> test system (Fig. 1A) produces a quantitative test result between 30 and 1000 µg of calprotectin/g of stool which covers the clinically relevant range of this biomarker. The result is also presented by a traffic-light system (Fig. 1B), set by the treating physician, in which the green light represents a NORMAL result (<100 µg/g), the yellow light a MODERATE or grey zone result (100-300 µg/g), and the red light a HIGH result (>300 µg/g) by default.

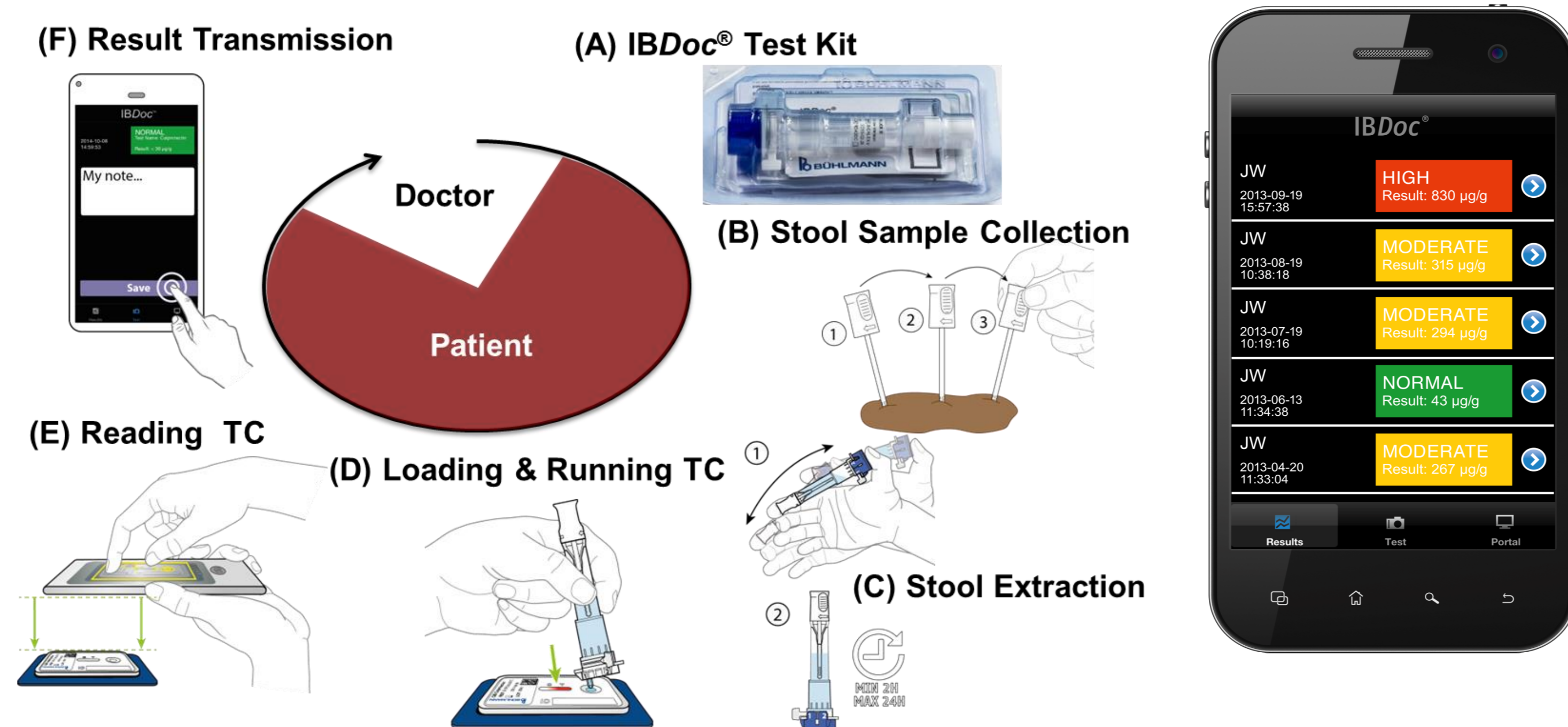


Fig. 1A: *IBDoc*<sup>®</sup> home testing system

Fig. 1B: Traffic-light system

### *IBDoc*<sup>®</sup> performed by lay users vs laboratory professionals

Twenty-six stool samples in total were analyzed by 31 lay users and 2 laboratory professionals both using the *IBDoc*<sup>®</sup> home test. The quantitative results of the lay users were correlated to the results of the professionals showing a slope of 0.99 by Passing-Bablok fit (Fig. 2A), and a bias of -1.5% and R<sup>2</sup> of 0.945 by Bland-Altman difference plot (Fig. 2B). The total within-class agreement (TA) of performing the *IBDoc*<sup>®</sup> between lay users and laboratory professionals was 96.8% (Fig. 3; blue-shaded fields) with 0% false positive (red instead of green traffic-light) and 0% false negative rates (green instead of red traffic-light).

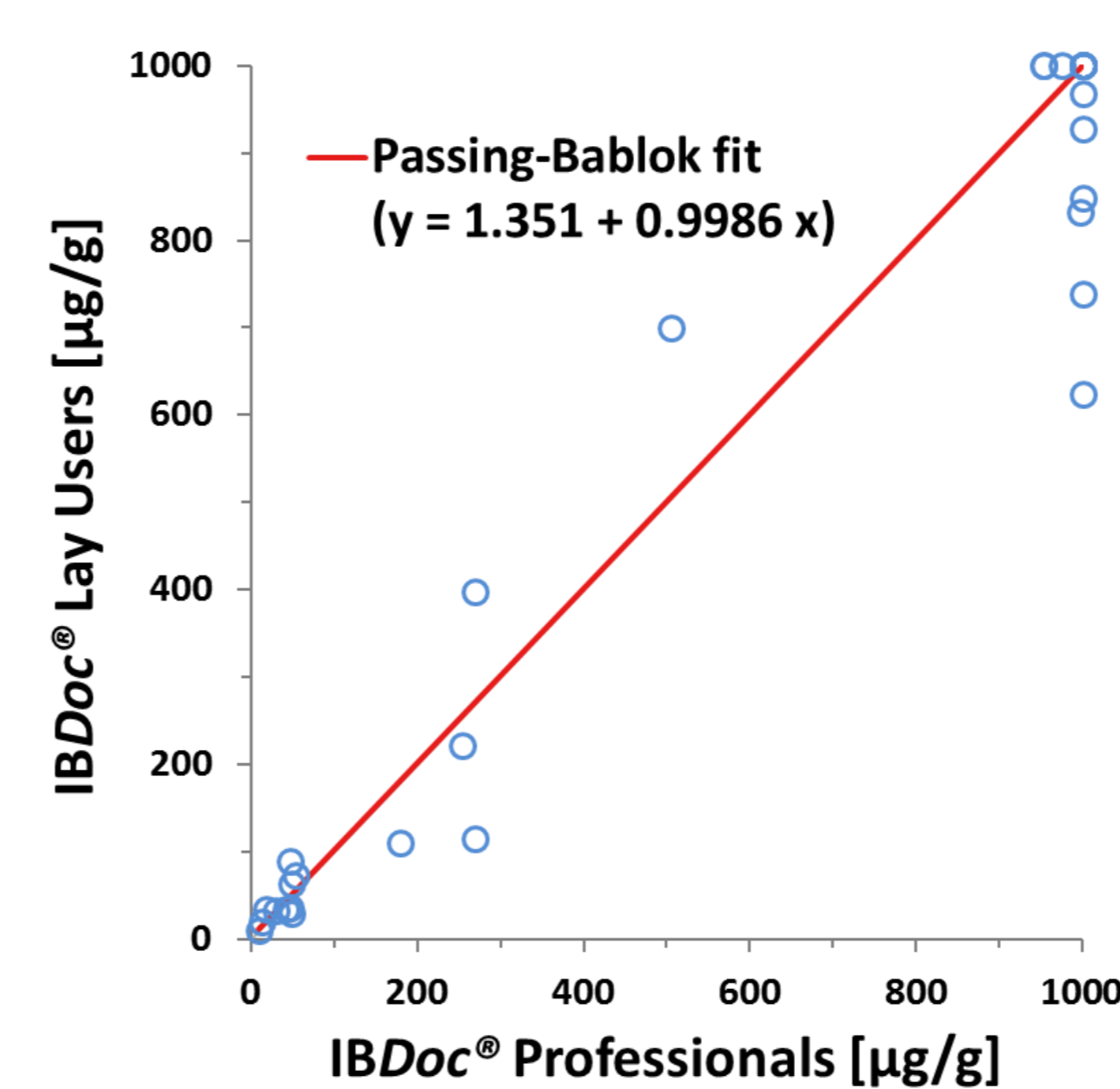


Fig. 2A: Scatter Plot of *IBDoc*<sup>®</sup> results

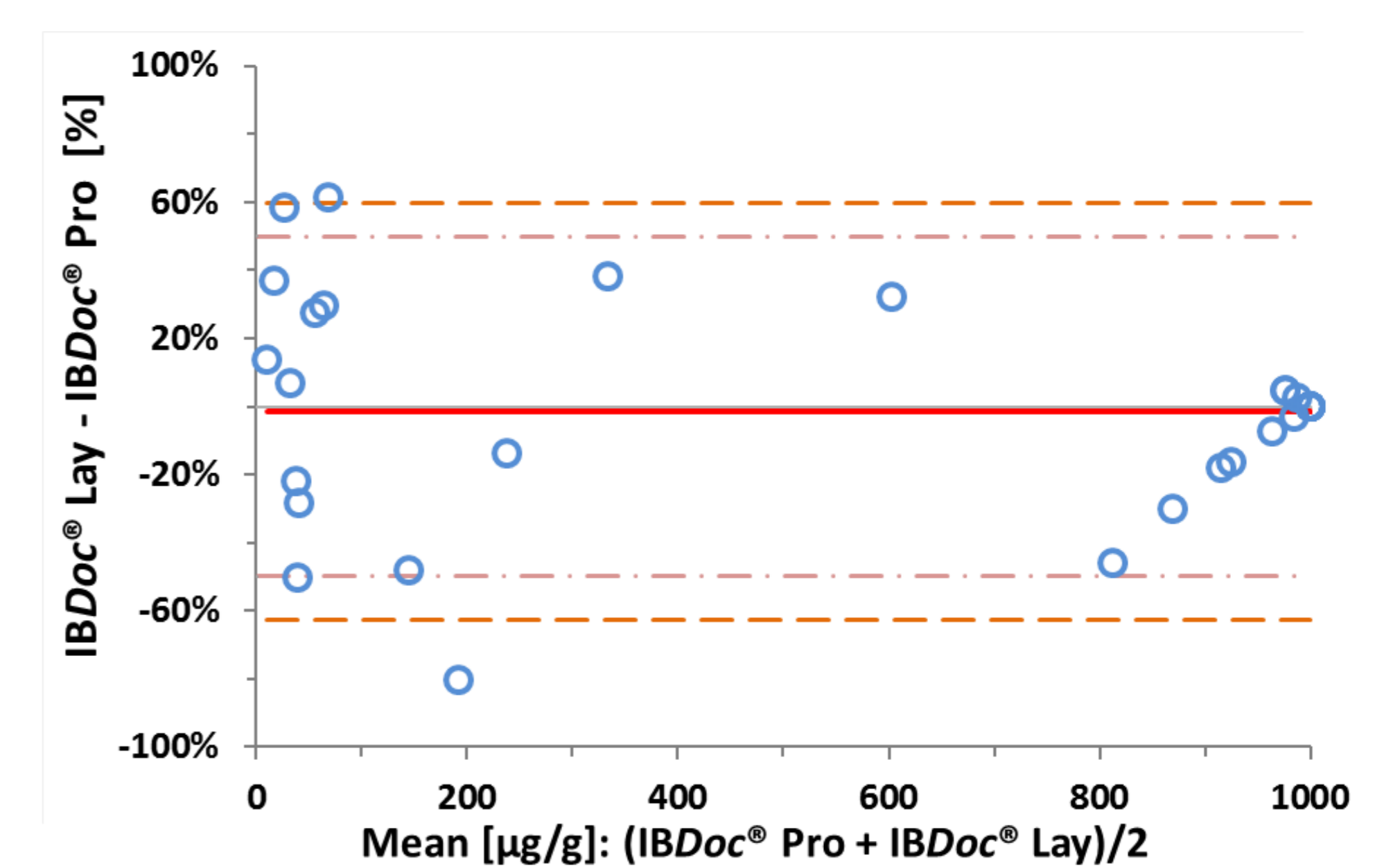


Fig. 2B: Bland-Altman plot of *IBDoc*<sup>®</sup> results. Red line, mean difference (bias); orange line, 95% CI, pink line, ±50% allowance limits

### Validation of the key components of the *IBDoc* test

The *CALEX*<sup>®</sup> Valve stool collection and extraction (Fig. 1A, steps B & C), the running and measuring of the TC with a smartphone (Fig. 1A, steps D & E) as compared to the Quantum Blue<sup>®</sup> reader (by professionals) and the combination of *CALEX*<sup>®</sup> Valve extraction and TC measurement with smartphone (Fig. 1A, steps B to F) were performed by 31 lay users and by 2 laboratory professionals. The entire *IBDoc*<sup>®</sup> test (Fig. 1A, steps B to F) done by lay users was also compared with a conventional stool weighing method and extraction with a vortexing machine combined with a routine, standard *fCAL*<sup>™</sup> ELISA (BÜHLMANN, Switzerland) in a second, independent professional laboratory. All statistical analyses are presented in Table 1.

Component/Step	Quantitative			Agreement (Traffic-Light)		
	Slope	Bias	R <sup>2</sup>	TA	FP	FN
<i>CALEX</i> <sup>®</sup> Valve (Lay) vs <i>CALEX</i> <sup>®</sup> Valve (Pro)	1.03	6.6%	0.976	87.1%	0.0%	0.0%
Smartphone (Lay) vs Quantum Blue <sup>®</sup> (Pro)	0.92	-20.8%	0.964	90.3%	0.0%	0.0%
<i>IBDoc</i> <sup>®</sup> Home (Lay) vs <i>fCAL</i> <sup>™</sup> ELISA Lab (Pro)	0.94	-16.9%	0.846	93.5%	0.0%	0.0%

Tab. 1: Comparison of the performance of *IBDoc*<sup>®</sup> key components/steps between lay users and professionals. Samples measured above the upper limit of 1000 µg/g were excluded from the quantitative analyses (n=14-16 results). Slope was calculated by Passing-Bablok fit; bias and R<sup>2</sup> by Bland-Altman; TA, total agreement; FP, false positive (>300 instead of <100 µg/g); FN, false negative (<100 instead of >300 µg/g).

IBDoc <sup>®</sup> Lay User	IBDoc <sup>®</sup> Laboratory Professional			
	Normal <100	Moderate 100-300	High >300	
Normal <100	10	0	0	10
Moderate 100-300	0	3	0	3
High >300	0	1	17	18
	10	4	17	31

Fig. 3: Agreement of *IBDoc*<sup>®</sup> results between lay users and professionals

## CONCLUSIONS

- *IBDoc*<sup>®</sup> is the first complete and validated (CE-IVD) test system which allows the IBD patient to monitor and follow his inflammatory status by measuring the IBD biomarker, fecal calprotectin, using his/her own smartphone. It is the first self testing device of its kind.
- There is no difference in the qualitative test results generated by lay users as compared to the results of laboratory professionals.
- The performance of the smartphone-based *IBDoc*<sup>®</sup> home testing system is comparable to professional, laboratory-based methods.