Improved Detection of Clinically Relevant Wound Bacteria Using Autofluorescence Image-Guided Sampling in Diabetic Foot Ulcers

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INTRODUCTION

Chronic wounds negatively affects patient quality of life and strain already burdened global health care systems. Standard of care for diagnosing wound infections involves bedside assessment of clinical signs and symptoms (CSS). In CSS-positive wounds, identification and quantification of bacterial species and antibiotic susceptibility are achieved by wound sampling. Standard Levine technique swabbing samples the wound bed, however treatment-relevant bacteria in the wound periphery or other regions are not collected or identified. Moreover, microbiology reports are typically not available for 3-5d after swabbing, at which point the biology and bioburden of the wound is no longer the same. In cases of asymptomaticity, CSS are insufficient for identifying bacterial loads and early opportunities to treat and improve outcomes are missed. The clinic need to ameliorate microbiological swabbing of chronic wounds and their subsequent treatment is significant and unmet.

OBJECTIVE

To evaluate real-time autofluorescence (AF) imaging using the K2 device to visualize bacteria and guide wound swabbing during the clinical assessment of DFUs compared to standard CSS plus Levine techniques swabbing of the same wound.

METHODS

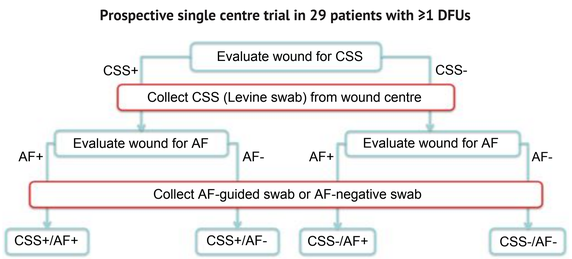

Figure 1. Schematic of Clinical Workflow

Figure 2. K2 Imaging device

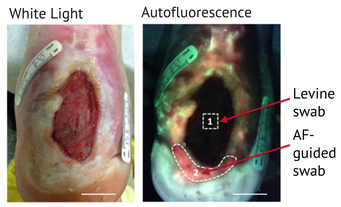

Figure 3. Wound sample locations

RESULTS

Table 1. Participant & sample summary

Patient Characteristics	
Patients consented (n)	33
Withdrawn	4
Patients analyzed (n)	29
Age (years) (mean ± SD)	63 ± 12
Male (n, %)	27 (93.1)
Female (n, %)	2 (6.9)
DFUs (total)	33
Assessments*	52
Swabs (total)*	128
CSS swabs	53
AF swabs	75
First Visit swabs*	65
CSS swabs	28
AF swabs	37

* Not including swabs with *P. aeuroginosa* only.

Table 2. Diagnostic accuracy measures for identifying clinically relevant bacteria

	CSS (n = 27)	AF Imaging (n = 27)	p-value
TP	8	7	
FN	3	2	
TN	6	14	
FP	10	4	
Sensitivity	0.73 (0.41,0.91)	0.78 (0.42,0.94)	0.82
Specificity	0.38 (0.18,0.62)	0.78 (0.54,0.91)	***0.0043***
PPV	0.44 (0.24,0.67)	0.64 (0.34,0.86)	0.22
NPV	0.67 (0.33,0.89)	0.88 (0.61,0.97)	0.2
Accuracy	0.52 (0.34,0.7)	0.78 (0.59,0.9)	***0.048***
DOR (adj.)*	3.07 (0.93, 10.14)	7.67 (2.6, 22.6)	0.29
p-value	0.066	***0.00022***	

Swabs were obtained at a patient's initial visit (n = # of swabs) from the wound center or periphery using CSS or AF imaging, respectively. DOR calculated for all visits (n=128 swabs). *Adjusted for repeat visits within a patient.

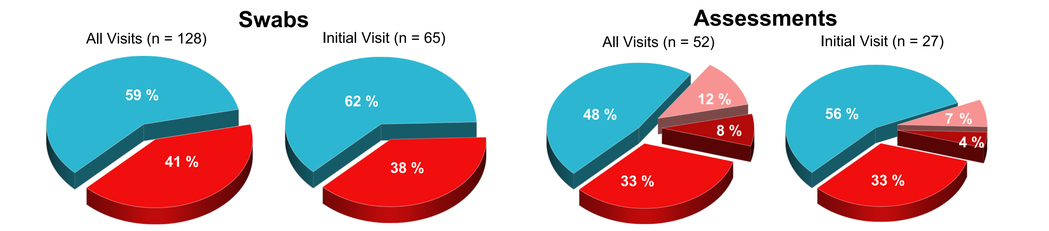

Figure 3. Prevalence of moderate and/or high bacterial load. Proportion of swabs (left) and DFU assessments (right) with moderate and/or high bacterial load (bacteria present) across different wound locations (centre and/or periphery).

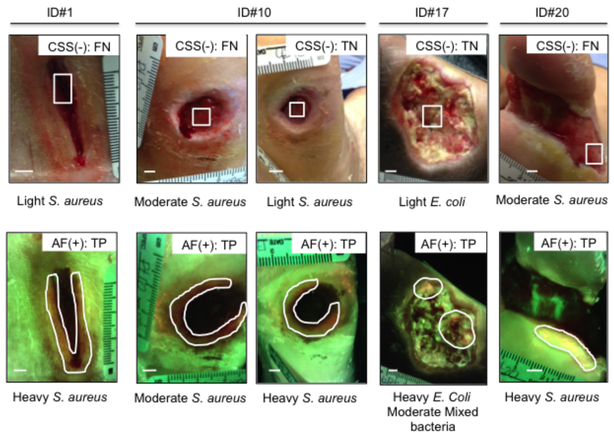

Figure 4. CSS alone fails to detect wounds with moderate and/or heavy bacterial growth. Images of the four DFUs identified as negative for CSS of infection (top panel) but accurately identified as positive for moderate to heavy bacteria growth by AF imaging (bottom panel). White boxes (top panel) indicate area where Levine techniques swab was performed. White regions of interest (bottom panel) indicate areas identified as red fluorescent. Scale bar: 0.5 cm.

CONCLUSIONS

1. There is a clear unmet need for improved standardized and objective methods for identifying infected wounds and guiding sampling (Levine, Z-technique, or biopsy) at the point-of-care.
2. AF imaging of DFUs performed at the bedside using the handheld K2 device:
   - detects clinically significant moderate and/or heavy growth of bacteria based on endogenous red AF
   - more accurately samples wounds compared to standard of care (78% vs. 52%), and
   - performs well as a diagnostic test (DOR = 7.67, p = 0.00022)
3. AF imaging allows for a more objective assessment of wound bioburden, making it more accurate and reproducible between different users at the point-of-care.
4. AF imaging directs clinicians to swab in wound areas not typically targeted by standard of care.
5. AF imaging is ~7x more likely to indicate a swab is required (red AF+) when moderate/heavy growth of bacteria is present than it is to indicate that a swab is required in an area of no/occasional/light bacterial load in a wound.

FUTURE PLANS

Prospective randomized controlled trial to evaluate the effect of AF-guided intervention (guided-swabbing and -debridement) on complete wound healing at 12 wks.

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