Targeting Curettage Debridement to Regions of Bioburden in Diabetic Foot Ulcers with Real-time Bacterial Fluorescence Imaging

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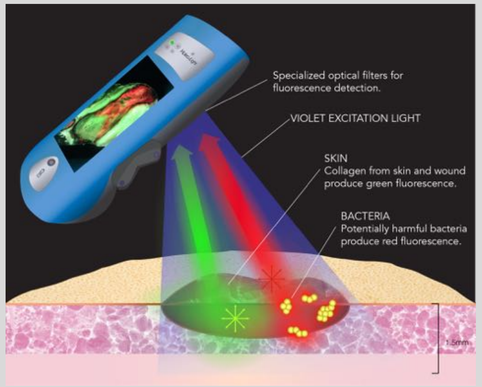
INTRODUCTION

- Current gold standard technique for tissue management in diabetic foot ulcers (DFUs) is regular sharp debridement to reduce bioburden, as this optimizes effectiveness of antimicrobials and stimulates wound healing[1].
- However, the extent of debridement required to reduce bioburden based on visual inspection is unclear, as point-of-care detection of bioburden relies primarily on visual inspection of wounds and subjective and suboptimal clinical signs and symptoms.
- To address this problem, fluorescence imaging has been used to visualize red-fluorescing bacteria in real-time at the bedside using a non-contact device[2-4].
- This study reports the use of bacterial fluorescence imaging to assess pre- and post-debridement bioburden and to specifically target secondary/additional debridement to regions of bacterial burden.

METHODS

Bacterial Fluorescence Imaging

- When excited by 405 nm violet light, tissues fluoresce **green** while bacteria fluoresce **red** (e.g. *Staphylococcus aureus*).
- This enables real-time, point-of-care detection and localization of bioburden (≥ 10^4 CFU/g) within and around wounds[2-4].



- Bacterial fluorescence imaging was incorporated into 22 routine wound assessments of 12 DFUs classified as "healable".
- Initial curettage debridement aggressively removed multiple layers of tissue on and around the wound, according to current best practices[1].
- Fluorescence images were acquired after initial debridement. When deemed clinically appropriate, fluorescence images were then used to target remaining regions of bioburden through additional debridement.

RESULTS

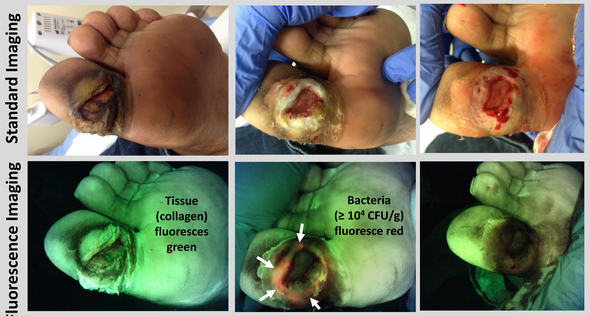
# of Wounds Debrided	
Initial debridement	Additional targeted debridement
20/22	17/20

Bacterial fluorescence observed in wound/periwound tissues		
Pre-debridement	After initial debridement	After additional, targeted debridement
11/22 (50%)	20/20 (100%)	16/17 (94%)

Note: Off-site bacteria was also observed in 3 of 22 wounds (in foot creases).

Summary: Curettage debridement was performed during 20/22 (91%) of wound assessments in this study.
Based on fluorescence images after initial debridement, in which **bacterial (red) fluorescence was present in 100% of DFUs**, clinician chose to more aggressively debride 17 of 20 DFUs, specifically targeting regions of bioburden.

Bacterial Fluorescence Guidance Enables More Aggressive Debridement Targeted Specifically to Regions of Bacterial Burden



Thick callus pre-debridement, no red fluorescence observed | **Initial debridement reveals red (bacterial) fluorescence** | **Red no longer detected after fluorescence guided debridement**

Case 1. 57 year old male with DFU on left toe. Patient self-treated DFU with an over the counter antibiotic ointment for two months prior to seeking treatment from a wound care practitioner. Patient lacked offloading footwear.

Initial curettage debridement was performed per standard of care, after which fluorescence images were acquired to assess initial debridement effectiveness. Bacterial (red) fluorescence observed throughout the periwound region led the clinician to debride more aggressively, specifically targeting the red fluorescing regions. Wound was debrided until red fluorescence was no longer observed.

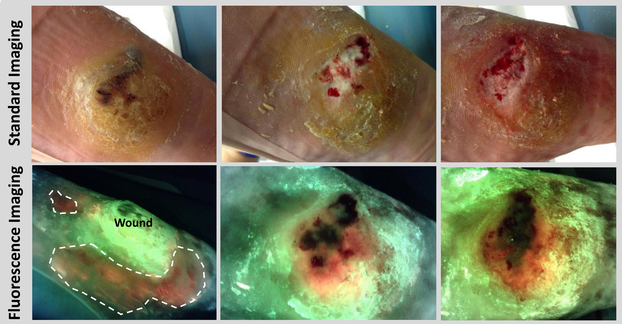
Bacterial Fluorescence Guides More Aggressive, Targeted Debridement and Insight for More Frequent Debridement

Pre-debridement | **Initial debridement** | **After fluorescence guided debridement**

Case 2. 52 year old male with small (0.3 cm^2) DFU on left toe. DFU has repeatedly closed/reopened due to patient's lack of proper offloading footwear.

Bacterial fluorescence (red, arrows) was observed pre-debridement, after initial standard of care debridement. Red fluorescence persisted after additional, targeted debridement. Based on the persistence of bioburden after aggressive debridement, clinician determined that patient required more frequent debridement (weekly) in addition to antimicrobial dressings.

Bacterial Fluorescence Guidance Reveals Contamination Within and Around a Plantar DFU



Pre-debridement (Bacteria surrounding DFU) | **Initial debridement** | **After fluorescence guided debridement**

Case 3. 82 year old male with plantar DFU, heavy callus builder.

Bacterial fluorescence (red) was observed surrounding the wound pre-debridement (circled), which prompted thorough cleaning of this region. Persistent bioburden after aggressive, targeted debridement of the wound demonstrated need for more frequent debridement.

CONCLUSIONS

- Red (bacterial) fluorescence was present in 100% of DFUs after initial, aggressive, standard of care curettage debridement. This is especially concerning given that red fluorescence equates to a bacterial load of 10^4 CFU/g or higher (i.e. moderate/heavy bacterial loads)[4].
- Thus, results of this study demonstrate that current best DFU debridement practices of visual inspection and clinician judgement:
  1. do not maximize removal of bioburden,
  2. leave behind an unacceptably high bacterial load (≥ 10^4 CFU/g) that is considered detrimental to wound healing[5], and
  3. fail to optimally prepare the wound for antimicrobial dressings/treatments.
- Incorporation of bacterial fluorescence imaging into routine DFU wound care resulted in more aggressive debridement. This specifically targeted regions of bioburden, and avoided unburdened tissue, providing a more optimal state for healing.
- Results highlight the potential of bacterial fluorescence imaging to dramatically improve current debridement practices by enabling point-of-care, bioburden based decision making on which tissue, and how much tissue, to selectively remove.

FUTURE DIRECTIONS

- The ultimate goal of debridement intervention is to increase (1) a wound's ability to heal and (2) wound healing rates[1,5]. Wound healing rates have not yet been incorporated into this study.
- In future, upon closure of these wounds, a retrospective analysis is planned to compare average healing rates in these twelve patients, debrided regularly under fluorescence guidance, with a separate cohort receiving standard of care only.

REFERENCES

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