Optimizing Hard-to-Heal Wound Healing: Integrating Near-Infrared Spectroscopy and Thermographic Imaging into the 7-Step Wound Management

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Introduction

Diabetes affects 30.3 million Americans (12.2% of adults). Up to 25% of people with diabetes will develop a foot ulcer, with 50% of those progressing to limb-threatening infection and 20% resulting in amputation. Diabetes increases the risk of amputation by over 330%. Each year, approximately 108,000 diabetes-related amputations occur, with a 50% chance of a second amputation within two years. The five-year mortality rate after amputation is 70%, comparable to lung cancer (86%) and higher than breast cancer (39%). Of the $116 billion spent annually on diabetes, one-third is attributed to managing complications such as foot ulcers and amputations.

Organized, multidisciplinary wound care programs have been shown to reduce lower extremity amputation rates by up to 72%. One such structured approach is the 7-Step Wound Management Framework. This framework supports timely decision-making, promotes consistency in care, and facilitates the integration of advanced therapies when standard care is insufficient. It serves as the foundation for organized programs that adapt to individual patient needs while aiming to optimize healing and reduce complications. This study evaluates the integration of Near-Infrared Spectroscopy (NIRS), thermography, digital imaging, and automated wound measurements into the 7-Step Wound Management Framework.

Methods

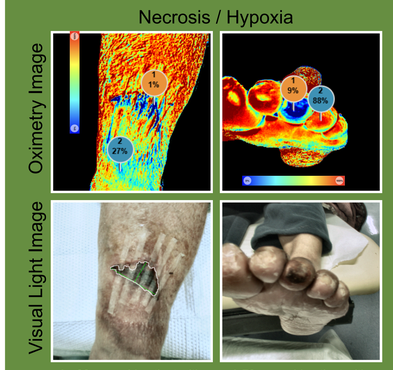
An FDA-cleared imaging device (MIMOSA Pro, MIMOSA Diagnostics Inc., Toronto, ON) was integrated into the 7-Step Wound Management Framework to support clinical decision-making with objective, real-time data. The device measures tissue oxygenation (StO_2) using near-infrared spectroscopy (NIRS), along with skin surface temperature and wound area. StO_2 data guided assessment of perfusion and evaluation of debridement quality, as well as suitability for interventions such as debridement or compression. Thermography served as a surrogate marker for infection and inflammation, and helped identify pressure points to inform offloading strategies. Imaging-derived wound characteristics supported dressing selection, while NIRS and thermography provided documentation of medical necessity for advanced therapies and enabled longitudinal tracking of treatment response.

Capture an image → Discuss imaging results to improve patient engagement → Track patient progress

Results: 7 Steps of Wound Management

Step 1 — Blood Flow

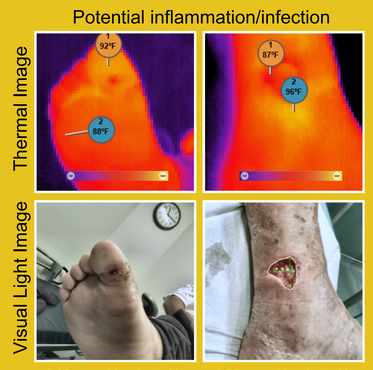
NIRS provides a non-invasive way to assess tissue perfusion and to confirm adequate blood flow before interventions like debridement or compression.



An 83-year-old patient with a wound on the right shin. *A 79-year-old patient with a wound on the left toe.*

Step 2 — Treat Infection

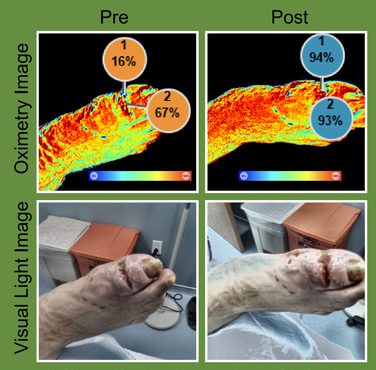
Thermography serves as an early surrogate marker of infection or inflammation, enabling timely intervention and reducing unnecessary wound cultures.



A 35-year-old patient with a wound on the right toe. *A 75-year-old patient with a wound on the ankle.*

Step 3 — Debridement

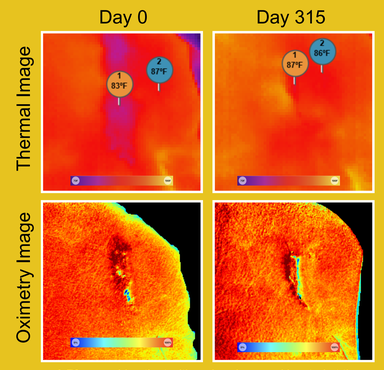
NIRS-guided debridement enables real-time assessment of tissue viability, optimizing removal of nonviable tissue while preserving healthy areas.



An 80-year-old patient with a wound on the right dorsal great toe. Following sharp debridement, an increase in StO_2 was observed.

Step 5 — Offloading

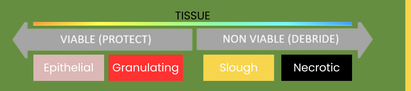
Thermography identifies high-pressure areas to guide offloading, while NIRS monitors tissue oxygenation changes resulting from pressure relief.



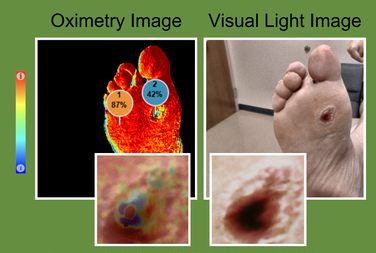
A 70-year-old patient with a chronic wound located at the sacral pressure point.

Step 6 — Host Factors and Dressing Selection

Key factors for dressing choice—such as infection status, tissue type (necrotic, slough, granulating), and wound size—can be assessed or supported through multimodal imaging.



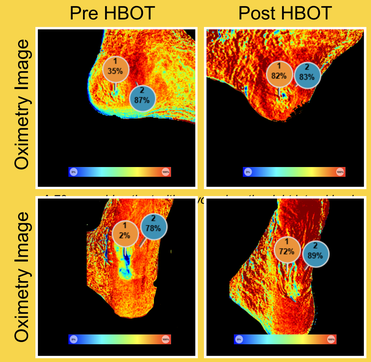
The Red-Yellow-Black (RYB) wound classification system uses color to categorize wound appearance and guide treatment decisions.



A male patient with a diabetic foot ulcer on the right plantar foot.

Step 7 — Advanced Modalities

If steps 1-6 don't lead to sufficient healing, advanced therapies like CAMPs or HBOT should be considered. NIRS and thermography help objectively monitor treatment response and guide therapy adjustments.



T: A 79-year-old patient with a wound on the right lateral heel; B: A 62-year-old patient with a wound on the right plantar foot.

Discussion & Conclusions

Advanced imaging with NIRS and thermography enhances multiple steps of the 7-Step Wound Management Framework by providing objective, real-time data that improve clinical decision-making. NIRS noninvasively assesses tissue perfusion and guides precise interventions like debridement, while thermography detects early signs of infection and identifies pressure points for targeted offloading. Together, they offer complementary insights into tissue health and wound environment. When standard care is insufficient, these tools also enable objective monitoring of advanced therapies such as CAMPs and HBOT, supporting timely adjustments. Integrating these technologies promotes personalized, data-driven wound care, leading to better outcomes, fewer complications, and more efficient use of healthcare resources.

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