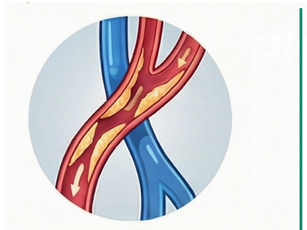
Near-Infrared Spectroscopy Imaging in Chronic Wound Care: A Comprehensive Review of Clinical Applications and Healing Insights

Alisha Oropallo, MD[1–4]; Alex G. Ortega-Loayza, MD, MCR[4–5]; Holly Korzendorfer, PT, PhD, CWS[4,6]; Francis James, BFA, SOC[4,7]; Peggy Dotson, RN, BS[4]; Anna Khimchenko, PhD[4,8]; Vickie R. Driver, DPM, MS[4,9]; and Sharon Eve Sonenblum, PhD[4,10]

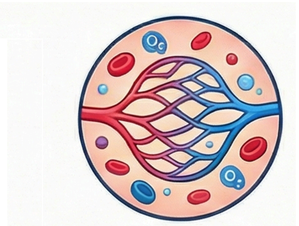
[1]Department of Vascular Surgery, Donald and Barbara Zucker School of Medicine, Hofstra/Northwell, Hempstead, NY, USA; [2]Feinstein Institutes for Medical Research, Manhasset, NY, USA; [3]Comprehensive Wound Healing Center, Department of Vascular and Endovascular Surgery, Northwell Health, Lake Success, NY, USA; [4]Wound Care Collaborative Community, Orlando, FL, USA; [5]Department of Dermatology, Oregon Health & Science University, Portland, OR, USA; [6]Doctor of Physical Therapy Program, Marist University, Poughkeepsie, NY, USA; [7]Independent Advisor and Medical Color Science Specialist , New Orleans, LA, USA; [8]MIMOSA Diagnostics Inc, Toronto, ON, Canada; [9]Washington State University Elson S. Floyd College of Medicine, Spokane, WA, USA; [10]Nell Hodgson Woodruff School of Nursing, Emory University, Atlanta, GA, USA

Introduction

Chronic wounds remain a global healthcare challenge. Traditional vascular assessments are limited to macrocirculation and lack real-time microvascular insights. A critical limitation in effective wound care is the inability to accurately assess microvascular tissue health in real time.



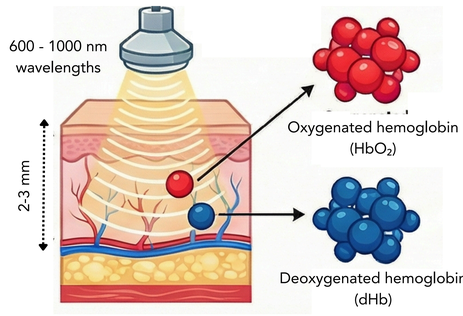
Macrovascular: Focus on large vessels, often inaccurate with calcification.
Examples: ABI, TBI



Microvascular: Evaluates microcirculation (vessels <100 µm in diameter) directly at the wound site.
Examples: HSI, MSI, SFDI, TCOM

ABI (Ankle-Brachial Index); TBI (Toe-Brachial Index); HSI (Hyperspectral Imaging); MSI (Multispectral Imaging); SFDI (Spatial Frequency Domain Imaging); TCOM (Transcutaneous oximetry)

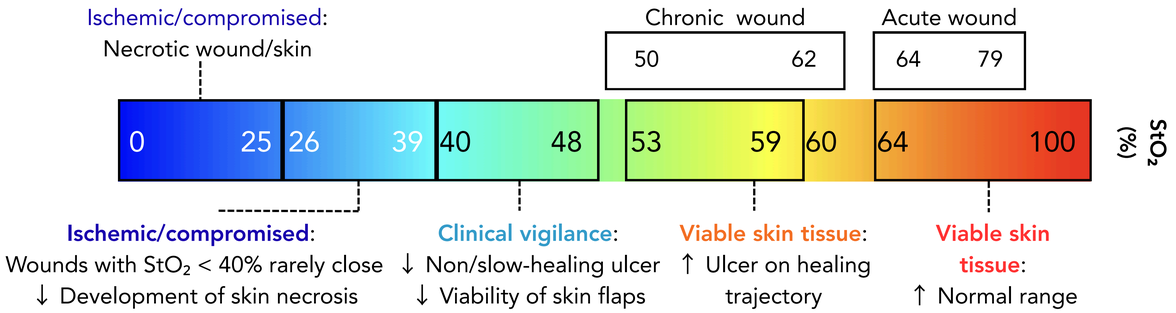
Near-infrared (NIR) imaging addresses this gap by providing non-invasive, two-dimensional maps of tissue perfusion to depths of 2–3 mm, enabling early detection of perfusion deficits. This review explains the clinical value and interpretation of NIR imaging in providing objective, real-time data for wound assessment and healing prediction.



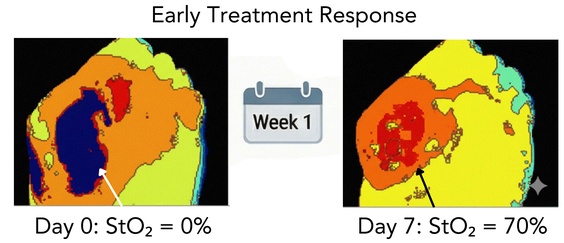
Tissue oxygen saturation (StO_2) = HbO_2 / (HbO_2 + dHb)

StO_2 serves as a valuable predictor of wound outcomes and treatment efficacy.

Quantitative Interpretation of StO_2 based on published literature



Single-Point Baseline Assessment: Evaluating Healing Potential. Tissue oxygenation images are typically displayed using a jet color map, in which blue indicates low oxygenation and red signifies high oxygenation. As shown in the figure above, the gradient transitions from blue/green (low) to yellow (mid-range) to orange/red (high). Studies show that higher StO_2 levels are associated with better healing potential.



Response to treatment: > 10% StO_2 change

Longitudinal Trajectory Tracking: Monitoring Treatment Response. Significant increases in tissue oxygenation during the early stages of treatment are linked to a positive clinical response and improved healing outcomes.

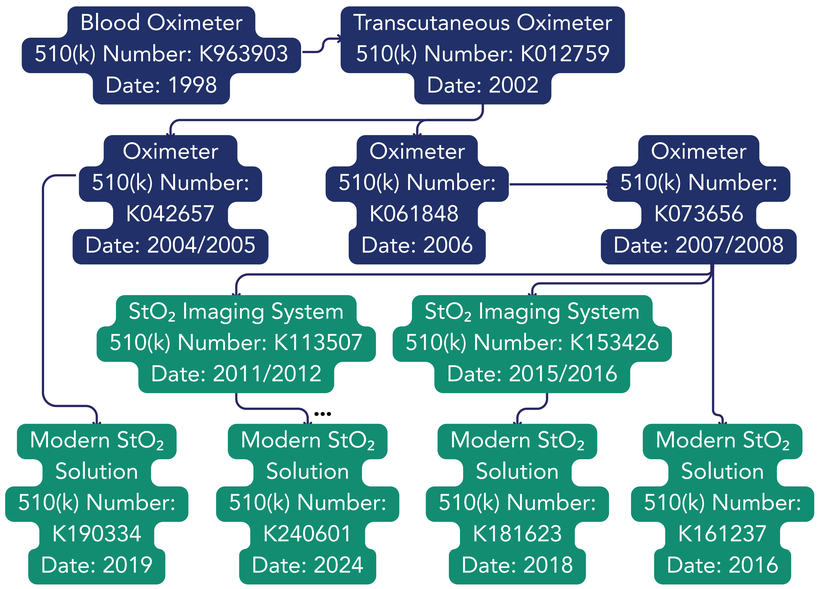
Key Clinical Applications

Application	Description: Key Insights and Benefits of NIRS
Healing Trajectory & Risk Stratification	An objective, non-invasive measure of tissue perfusion/oxygenation for wounds and surrounding tissues with potential for prediction of wound healing.
Vascular Assessment & Triage	To assess lower extremity blood supply and/or need for revascularization.
Surgical Wounds & Flap Monitoring	Enables real-time intraoperative perfusion mapping and post-operative monitoring.
Therapeutic Efficacy & Advanced Modalities	To monitor therapy efficacy (e.g. HBOT, TOT) or determine vascular sufficiency for effective wound healing and therapy success (e.g. CAMPs).
Future Directions: Early PI Detection	Detects DTIs and subdermal physiological distress, shifting care from reactive treatment to proactive prevention.

Key Clinical Applications of NIRS in Wound Care. NIRS imaging offers real-time, objective data on tissue oxygenation and perfusion, making it particularly useful for monitoring wounds of varying etiologies and assessing the efficacy of various treatment modalities.

HBOT (Hyperbaric Oxygen Therapy), TOT (Topical Oxygen Therapy), CAMPs (Cellular and/or Tissue-Based Products), DTI (Deep Tissue Injury); PI (Pressure Injury)

From Early Predicates to Modern Solutions



FDA 510(k) Clearance Process from Early Predicates to Modern Imaging Solutions: Figure illustrates the regulatory pathways and predicate devices for several MUD-designated tissue saturation oximeters

Discussion & Conclusion

NIR imaging advances wound management by providing real-time, noninvasive, and objective data on tissue oxygenation and perfusion. It may objectively complement the standard percentage area reduction assessments during the wound treatment process, potentially reducing healing times and costs. Limitations include artifacts from skin tone or motion potentially mitigated by algorithms and lack of standardization. Future directions involve AI integration for predictive models and combination with other imaging for holistic care.

WOUND CARE Collaborative Community

Tel: 407.337.9222
info@woundcarecc.org
https://www.woundcarecc.org/

Oropallo A, Ortega-Loayza AG, Korzendorfer H, et al. Advancing chronic wound care with near-infrared spectroscopy imaging: clinical applications, measurement parameters, and insights into healing dynamics. Wounds. 2025;37(10):384-392. doi:10.25270/wnds/25041