A Comprehensive Scoping Review on the Use of Point-of- Care Infrared Thermography Devices for Assessing Diabetic Foot Ulcers

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Introduction

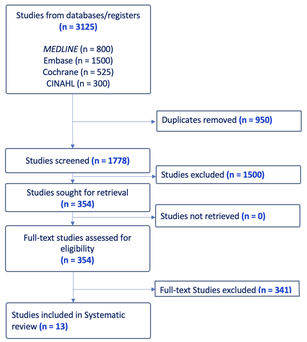
- The prevalence of diabetic foot ulcers (DFU) among the diabetic population ranges from 4-10%, with an annual incidence of 1-4% and a lifetime incidence as high as 25%.[1,2] The consequences of DFU are severe, with an increased risk of infection, hospitalization, and lower extremity amputation, as well as a 5-year mortality rate of 50-70%[2]
- Thermograms can detect small temperature variations that can signal healing progress, the onset of inflammation, or tissue necrosis, often before clinical symptoms appear and facilitating earlier interventions with more targeted management strategies[3,4]
- Infrared thermography (IRT) provides a non-contact, point-of-care (POC) method to quantify skin-surface temperature for DFU wound assessment and monitoring[3]
- Advances in portable, smartphone-compatible IRT devices have enabled bedside monitoring, but integration into standard DFU care remains limited and few studies have evaluated this[5]

Objectives

- Synthesize existing evidence from studies on point-of-care infrared thermography devices used for assessing DFUs.
- Descriptively summarize findings related to diagnostic thresholds for DFU assessment, and evaluate thermography's current role in predicting DFU healing, identifying complications, and monitoring
- Identify current research gaps and challenges to establish thermography as a standard clinical tool for DFU management

Methodology

- A scoping review was performed following the Arksey & O'Malley framework and PRISMA-ScR guidelines
- The literature search was conducted across four major databases: Medline, Embase, CINAHL, and Cochrane Library (search to 2024) of publicly published and peer-reviewed sources
- The search strategy focused on human studies evaluating point-of-care non-contact infrared thermography devices for DFU wound assessment; all study designs were eligible
- Data screening and extraction was conducted in duplicate using Covidence; data extraction captured on study design, device type, sample size, outcomes, key findings
- The final synthesis of findings was descriptive, presented in narrative and tabular formats



Results

Studies Overview

- 13 studies were included, majority had a sample size (median n = 24; range 1 - 100)
- Evidence level was mostly Level III - IV (small observational cohorts or pilot studies)
- 54% (7/13 studies) included control groups

Early Detection & Complication

- Thermography detected early thermal changes in acute DFUs before they were clinically visible or symptomatic, and identified chronic temperature increases associated with infection risk
- ΔT of 3°F (~1.67°C) helped predict wound-related infection in DFUs[6,7]

Predicting Healing Trajectory

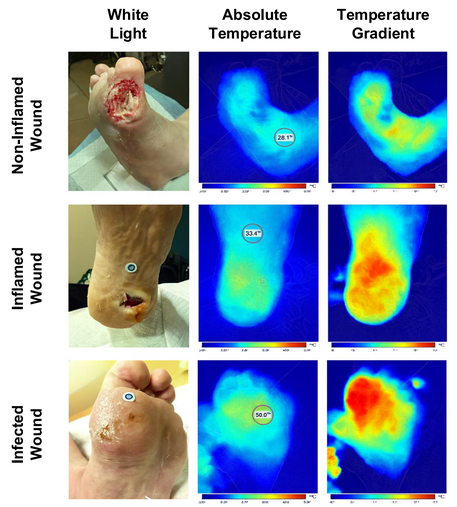
- **Weekly thermal pattern changes to predict healing:** DFU periwound changes visualized by thermography from week 1 to week 2 could predict wound healing trajectory (p = 0.036)[8]
  - Isothermal area ratio was a strong predictor of 4-week healing outcomes, outperforming other measures

Evaluating Treatment Response

- **Post-revascularization:** Thermography could detect temperature increases in limbs treated with endovascular revascularization and indicated treatment success[9]
  - Significant limb temperature rise detected by thermography predicted perfusion improvement and treatment success[9]
- **Hyperbaric oxygen therapy ($HBOT_2$):** Thermography was also shown to be effective in predicting positive responses to $HBOT_2$, by detecting post-therapy temperature increases[7]
- 3-D thermography in conjunction with AI algorithms improved detection of inflammation and predicted ulceration risk[10]

Barriers to Clinical Integration

- Current limitations to widespread clinical adoption include challenges related to reimbursement, training needs, and integration with Electronic Medical Records (EMR)
- Training and reimbursement challenges
- Inconsistent adjustment for skin-tone variability



Thermal imaging patterns of diabetic foot ulcers illustrating three distinct presentations corresponding to non-inflamed, inflamed, and infected wounds. Each row demonstrates paired white-light, absolute temperature, and temperature-difference images, highlighting characteristic thermographic profiles that differentiate inflammatory and infectious states.

Discussion

- POC thermography can provide immediate, non-invasive physiological insights, aiding in early detection of complications and delayed healing
- It is particularly valuable in aiding timely clinical decision-making when managing acute DFUs by detecting thermal changes before visible symptoms or complications appear
- Despite promising findings, the current evidence base for DFUs is constrained by small sample sizes, observational designs, and overall heterogenous methodology
- Advancements in EMR integration, standardized protocols, and clinician training are crucial to establishing thermography as a standard clinical tool in DFU care
- Future studies must prioritize diverse populations and explore the influence of skin tone to develop protocols that support equitable, bias-reduced assessment across populations

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