

Technology in wound healing assessment

PeriFlux 6000 and PeriCam PSI

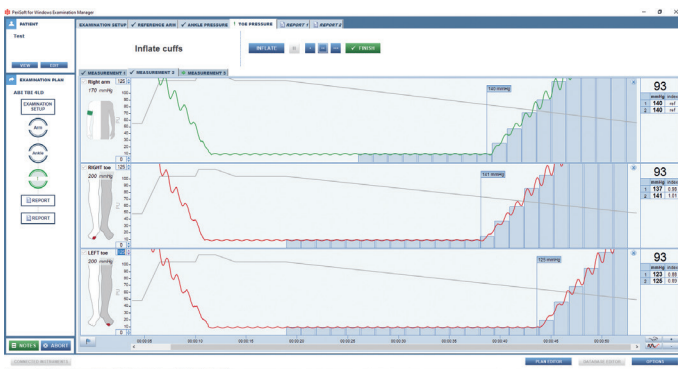
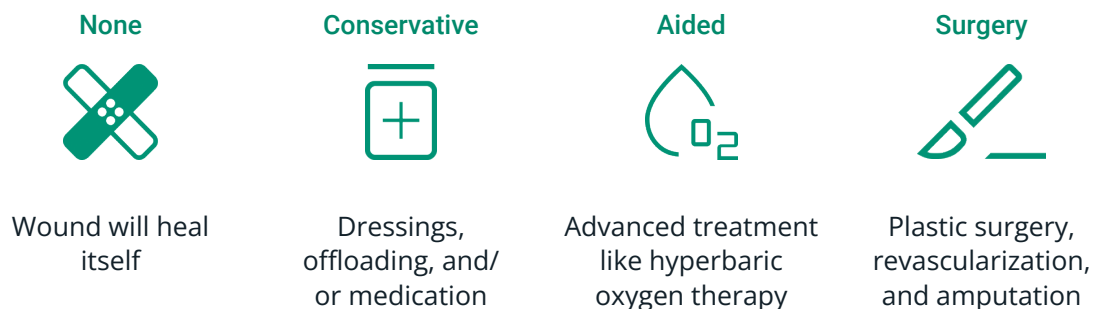




To assess the potential of a wound to heal, clinicians leverage their expertise, established understanding of the stages of wound healing, visual inspections, and easy-to-perform touch tests like capillary refill. But not all wounds or patients are the same. Impaired microcirculation — due to a burn, for example, or

conditions like diabetes and peripheral artery disease (PAD) — affects healing potential as it reduces the level of essential oxygen and nutrients at the wound site [1]. Technology provides clinicians with essential tools to address such complexities systematically, noninvasively, and even without having to touch the patient.

Wound healing therapies can be divided into several approaches with rising impact on the patient and healthcare systems:



This toe-pressure graph is system-generated for illustrative purposes only

The data technology captures can be used to generate graphs and images that provide clinicians with useful insights

The role of technology in wound healing assessment

A clinician's initial observation is the critical first step in the diagnosis and treatment of wounds. Biomarkers such as skin discoloration and temperature provide insight. Physicians can ask patients about their pain levels, test for sensitivities, and leverage readily available measurements like blood pressure, body temperature, respiration rate, and pulse to create a baseline assessment of their patient's healing potential and possibly determine an initial course of therapy.

However, these kinds of basic observations are limited as they can't capture the physiology of a person's macro- and microcirculatory systems that affect healing potential. And that's where well-established technologies like laser speckle contrast imaging [2], TcpO2 [3], and laser Doppler [4] come into play. Such solutions provide objective and reproducible data that help clinicians direct care and readily assess how patients respond to treatment over time.

Innovation in healthcare

To be useful in a clinical setting, wound-assessment technology should promote:

- The most positive patient outcomes.
- Patient-centric care.
- Ease of use.

Laser Doppler flowmetry (LDF)

LDF leverages the Doppler shift effect to assess the speed and concentration of red blood cells in a person's microcirculatory system. When a laser is shone on a person's skin, the frequency spectrum of the reflected light reveals the level of perfusion in the person's microcirculation. LDF can be used in a wide range of wound assessment exams — macrocirculation measurements such as toe pressure, TBI, ankle pressure, and ABI, and microcirculation measurements such as SPP, TcpO2, and laser Doppler with heat provocation — for a comprehensive overview of the patient.

LDF leverages noninvasive probes and does not require contrast agents to measure perfusion, promoting ease of use and patient-centric care.



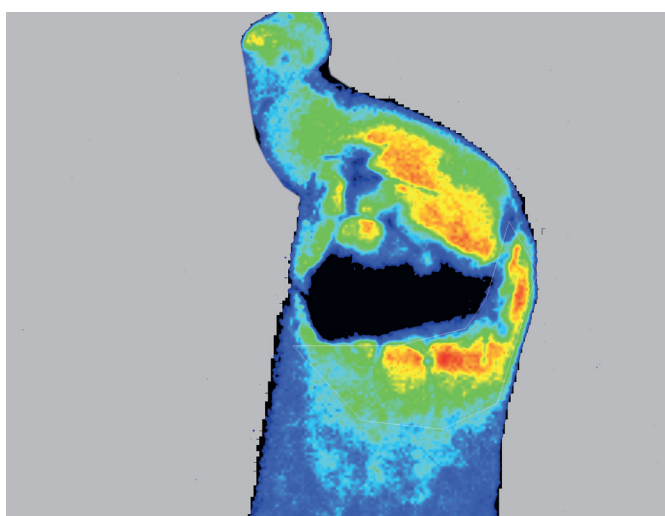
“Not all wounds or patients are the same



Transcutaneous oxygen pressure (TcpO2)

TcpO2 works by placing a specialized electrode at an area of interest on the patient. It heats the site to 44 or 45°C (111.2 or 113°F), causing oxygen to diffuse through the skin. The electrode measures how much oxygen is released, providing an indication of the level of free oxygen in the tissue, which in turn provides an indication of wound healing potential.

Like LDF, TcpO2 is noninvasive and does not require contrast agents, promoting patient-centric care and ease of use. With thresholds for assessing wound healing potential and use with hyperbaric oxygen therapy [3] TcpO2 has become an established element of patient assessment.



Laser speckle contrast imaging (LSCI)

Based on similar principles as LDF, LSCI is both a noninvasive and contactless technique for measuring tissue perfusion. The technology captures perfusion data and uses it to generate a 2D image of the tissue in real time. Because laser-based imaging does not require contact with the skin, it is well-suited for measuring perfusion in wounds, which isn't feasible with contact-based technologies. And like LDF and TcpO2, LSCI requires no contrast agents. The contactless nature of the technology promotes ease-of-use and patient-centric care. LSCI is applicable in the assessment of microcirculation for people with diabetic foot ulcers [5] and performs well in the prediction of healing potential in burns [6].

Why measure perfusion in the microcirculatory system

Patient complications associated with slow or failed wound healing can be devastating.

- The AHA annual figure for lower-extremity amputations ≈150,000 [7] translates to a limb lost every 3.5 minutes in the US.
- 43% of patients with critical limb ischemia require reintervention 3 years after revascularization [8].
- 2 out of 3 patients with initial CLI symptoms should be considered for revascularization [9].
- On average, perioperative complications arise in 45% of oncoplastic breast surgeries [10] [11].

“Time is tissue



Limb loss



Multiple surgeries



Revascularization



Necrosis

Looking at the big picture, non- or delayed-healing wounds affect the quality of life for patients as well as the people around them, including the financial implications of amputation and surgery for the individual and the healthcare system.

Technology in practice

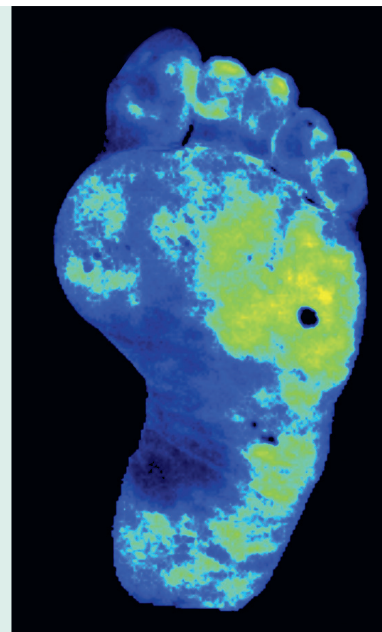
Here we present three hypothetical cases to illustrate how technology-based microcirculation measurements support decision-making in determining the most appropriate wound healing therapy.

Case A

The patient is a 68-year-old man with diabetes, neuropathy, and a foot ulcer on the sole of his foot. His clinician has observed the wound and noted no significant recent improvement despite normal ABI and toe pressure readings.

To determine effective treatment, a skin perfusion pressure (SPP) or TcpO₂ assessment of the patient's microcirculation is a possible next step. The position of the DFU on the sole of the patient's foot means SPP is preferable in this case.

Lastly, the clinician uses laser speckle contrast imaging to inspect the wound. The image shows elevated microcirculation around the wound which together with the patient's SPP reading (substantially above 40mmHg), indicates good microvascular supply to the tissue, and that the ulcer is neuropathic and should heal spontaneously if pressure is removed.

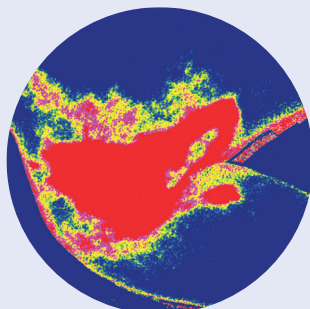


Case B

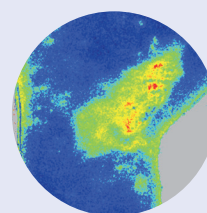
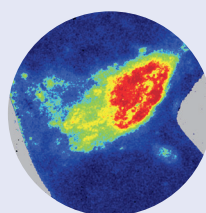
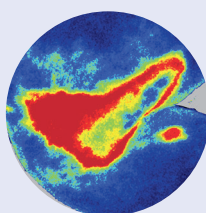
The patient is a 50-year-old woman with diabetes, and a DFU on the dorsal side of her left foot that is slow to heal. She has a toe pressure of 45 mmHg, ankle pressure of 150 mmHg, and an ABI of 1.2. Given the patient's low toe pressure and normal ABI/ankle pressure readings, her clinician suspects that media sclerosis may cause her ankle pressure readings to be falsely elevated. The clinician orders a TcpO₂ exam with oxygen provocation to determine her microvascular capacity. Her Tcpo₂ baseline of 39 mmHg, which reaches 110 mmHg during 100% oxygen inhalation indicate that hyperbaric oxygen therapy may be appropriate [12].

Case C

A child has come into a local clinic with a burn wound. On visual inspection, the clinician determines that the wound will most likely heal by itself. To complement their visual inspection, the clinician uses a laser speckle contrast imager to inspect perfusion in the burn. The resulting burns color scale image suggests that the wound will heal spontaneously [6]. Follow-up measurements show the progression of the wound up to 15 days, confirming healing.



Burns color scale



Generic LSCI color scale

Our instruments – laser Doppler/TcpO2

PeriFlux 6000 Combined System

The combined configuration of PeriFlux 6000 is a versatile solution designed with patients in mind. Leveraging laser Doppler (LD) and laser Doppler with heat provocation, it supports a broad range of macro- and microcirculation exams that can be conducted simultaneously, reducing time spent in the exam room. All measurements are delivered in a comprehensive patient report with DICOM/HL7 to ensure communication with centralized patient management systems.



Perimed offers comprehensive solutions for wound healing assessment including laser speckle contrast imaging and combined laser Doppler flowmetry and TcpO2 solutions.

Exams include:

	Macrocirculation exams	Microcirculation exams
Lower arterial	Toe pressure and TBI	TcpO2
	Ankle pressure and ABI	SPP
	Segmental pressure	Laser Doppler with heat provocation
	Pulse volume recording (PVR)	
	Treadmill/exercise test	
	Penile pressure	
Upper arterial	Finger pressure	TcpO2
	Raynaud's syndrome	SPP
	Thoracic outlet syndrome	Laser Doppler with heat provocation

Our instruments – laser speckle contrast imaging

PeriCam PSI

Our blood perfusion imager leverages laser speckle contrast imaging (LSCI) technology to assess microcirculatory perfusion. The solution combines dynamic response and high spatial resolution in one instrument, providing quantitative data, real-time graphs, and video recordings of perfusion in the patient's tissue.



References

- [1] Li, W.W., Carter, M.J., Mashiach, E. and Guthrie, S.D. (2017), Vascular assessment of wound healing: a clinical review. *Int Wound J*, 14: 460-469. <https://doi.org/10.1111/iwj.12622>
- [2] Heeman W, Steenberg W, van Dam G, Boerma EC. Clinical applications of laser speckle contrast imaging: a review. *J Biomed Opt*. 2019;24(8):1-11. <https://doi.org/10.1117/1.JBO.24.8.080901>
- [3] International Diabetes Federation. IDF Diabetes Atlas, 10th edn. Brussels, Belgium: 2021. Available at: <https://www.diabetesatlas.org>
- [4] Micheels, J., Alsbjorn, B., & Sorensen, B. (1984). Laser doppler flowmetry. A new non-invasive measurement of microcirculation in intensive care?. *Resuscitation*, 12(1), 31-39. [https://doi.org/10.1016/0300-9572\(84\)90056-x](https://doi.org/10.1016/0300-9572(84)90056-x)
- [5] Mennes, O. A., van Netten, J. J., van Baal, J. G., & Steenberg, W. (2019). Assessment of microcirculation in the diabetic foot with laser speckle contrast imaging. *Physiological measurement*, 40(6), 065002. <https://doi.org/10.1088/1361-6579/ab2058>
- [6] Dijkstra, A., Guven, G., van Baar, M. E., Trommel, N., Hofland, H. W. C., Kuijper, T. M., Ince, C., & Van der Vlies, C. H. (2023). Laser speckle contrast imaging, an alternative to laser doppler imaging in clinical practice of burn wound care derivation of a color code. *Burns : journal of the International Society for Burn Injuries*, 49(8), 1907-1915. <https://doi.org/10.1016/j.burns.2023.04.009>
- [7] Creager, M. A., Matsushita, K., Arya, S., Beckman, J. A., Duval, S., Goodney, P. P., Gutierrez, J. A. T., Kaufman, J. A., Joynt Maddox, K. E., Pollak, A. W., Pradhan, A. D., & Whitsel, L. P. (2021). Reducing Nontraumatic Lower-Extremity Amputations by 20% by 2030: Time to Get to Our Feet: A Policy Statement From the American Heart Association. *Circulation*, 143(17), e875-e891. <https://doi.org/10.1161/CIR.0000000000000967>
- [8] Darling, J. D., McCallum, J. C., Soden, P. A., Korepta, L., Guzman, R. J., Wyers, M. C., Hamdan, A. D., & Schermerhorn, M. L. (2017). Results for primary bypass versus primary angioplasty/stent for lower extremity chronic limb-threatening ischemia. *Journal of vascular surgery*, 66(2), 466-475. <https://doi.org/10.1016/j.jvs.2017.01.024>
- [9] Engelhardt, M., Boos, J., Bruijnen, H., Wohlgemuth, W., Willy, C., Tannheimer, M., & Wölfl, K. (2012). Critical limb ischaemia: initial treatment and predictors of amputation-free survival. *European journal of vascular and endovascular surgery : the official journal of the European Society for Vascular Surgery*, 43(1), 55-61. <https://doi.org/10.1016/j.ejvs.2011.09.010>
- [10] Garwood ER, Moore D, Ewing C, et al. Total skin-sparing mastectomy: complications and local recurrence rates in 2 cohorts of patients. *Ann Surg*. 2009;249(1):26-32. <https://doi.org/10.1097/SLA.0b013e31818e41a7>
- [11] Garwood, E. R., Moore, D., Ewing, C., Hwang, E. S., Alvarado, M., Foster, R. D., & Esserman, L. J. (2009). Total skin-sparing mastectomy: complications and local recurrence rates in 2 cohorts of patients. *Annals of surgery*, 249(1), 26-32. <https://doi.org/10.1097/SLA.0b013e31818e41a7>
- [12] Fife, C. E., Smart, D. R., Sheffield, P. J., Hopf, H. W., Hawkins, G., & Clarke, D. (2009). Transcutaneous oximetry in clinical practice: consensus statements from an expert panel based on evidence. *Undersea & hyperbaric medicine : journal of the Undersea and Hyperbaric Medical Society, Inc*, 36(1), 43-53. <https://pubmed.ncbi.nlm.nih.gov/19341127/>

About Perimed

With over 40 years of experience and unique competence in measuring blood perfusion with laser-based technologies, Perimed is a leader in medical solutions that generate insights to aid peripheral vascular diagnosis. We have over 4,000 installed instruments worldwide, operating in wound care departments, diabetic foot clinics, vascular centers, labs, and radiology — saving limbs, saving lives, and reducing human suffering.



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All specifications are subject to change without notice.

