SPP AND TCPO2

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A practical guide to measuring microcirculation for patient-centric care

Saving limbs, saving lives, reducing human suffering

A patient-centric approach

To determine the best course of treatment and address the complexity posed by individuals with diseases like diabetes and peripheral artery disease (PAD), modern guidelines include recommendations for **multiple macro- and microcirculation measurements**. Together with a systematic approach to testing and interpretation, multi-metrics promote positive outcomes for patients.

In this practical guide, we address the recommended measurements for microcirculation — skin perfusion pressure (SPP) and transcutaneous oxygen (TcpO2) — from a high-level practical standpoint, aiming to answer the questions we are often posed by clinical and non-clinical staff. We believe it will be of interest to anyone working in a vascular, wound, or diabetic center, but also to anyone looking to understand how technology delivers objective measurements and how those measurements guide treatment decisions.

At the end, you'll find a short overview of our solution, PeriFlux 6000, which supports both SPP and TcpO2 in addition to a range of macrocirculation measurements, including toe pressure and TBI, pulse volume recording (PVR), ankle pressure and ABI, and segmental pressure — delivering a comprehensive and objective overview of the patient's vascular status.

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Skin perfusion pressure

Skin perfusion pressure (SPP) is a diagnostic exam for assessing blood pressure in the microcirculatory system. It emerged as a clinical protocol in the 1960s [1]. Since then, advances in technology have transformed SPP from a complex and invasive procedure to the noninvasive and easy-to-perform exam it is today.

SPP values are primarily used as an aid in wound-healing prognosis — especially diabetic foot ulcers (DFUs) [2]. SPP values taken before and after revascularization help clinicians assess the effectiveness of surgery.

Measurement techniques have evolved over time, but today, laser Doppler — which assesses the movement of red blood cells in the capillaries and small arteries — has become the most widely used technology for measuring SPP [3].

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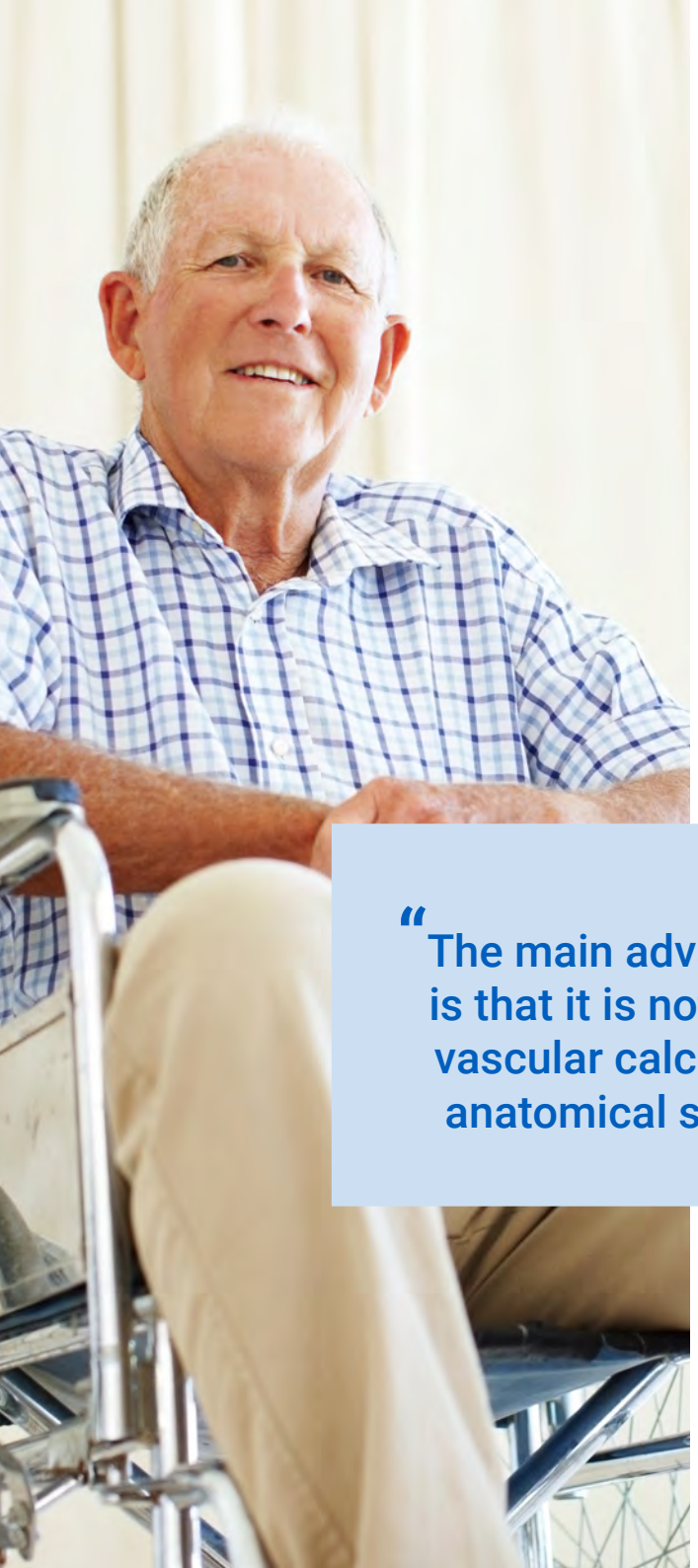
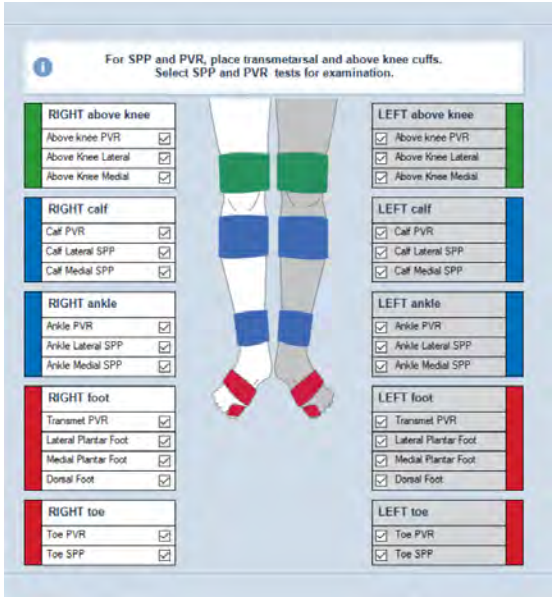
Placing a laser Doppler probe on the sole of the foot during patient preparation. To ensure accurate SPP values, the probe should be fully covered by the pressure cuff.



SPP in practice

SPP can be measured at multiple sites: on the foot (plantar, dorsal, and toes), on the ankle, and above and below the knee. Blood flow is occluded by placing a pressure cuff over the probe and inflating it above the patient's resting systolic pressure. The cuff is then gradually deflated until microcirculatory flow returns — this is the SPP value and is measured in millimeters of mercury (mmHg).

SPP can help identify ischemic areas (by, for example, using the angiosome concept, see Appendix B). Comparing SPP measurements in areas adjacent to a non-healing ulcer can reveal microcirculatory vascular deficiencies.



> "The main advantage of SPP is that it is not affected by vascular calcification and anatomical structure [3].

When to use SPP

Not all patients are the same, toe pressure, for example, isn't feasible for a person whose toes have been amputated. For patients with edema, callouses, or wounds on the sole or plantar region, SPP is the most applicable means for measuring the microcirculation.

Interpreting SPP results

The 2023 update of the IWGDF guidelines [4], includes SPP values for wound-healing prognosis, stating that values ≥ 40 mmHg can increase the probability of healing by up to 30%.

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Transcutaneous oxygen pressure

TcpO2 is a noninvasive diagnostic exam for assessing microcirculation by measuring the local pressure of oxygen released through the skin from the capillaries. It emerged in clinical devices in the late 1970s, primarily in neonatal care. The application of TcpO2 to peripheral vascular medicine came about in the mid-1980s. Insufficient oxygen in tissue predictably leads to impaired wound healing. As there are many other reasons why wounds don't heal (such as venous hypertension, infection, and inadequate nutrition), it's much easier to predict wounds that won't heal than wounds that will [5].

When limb salvage is no longer an option, TcpO2 is a reliable indicator of local ischemia and can be used together with other patient data to determine optimum amputation level [6] [7] — as distal as possible with the highest probability of healing.

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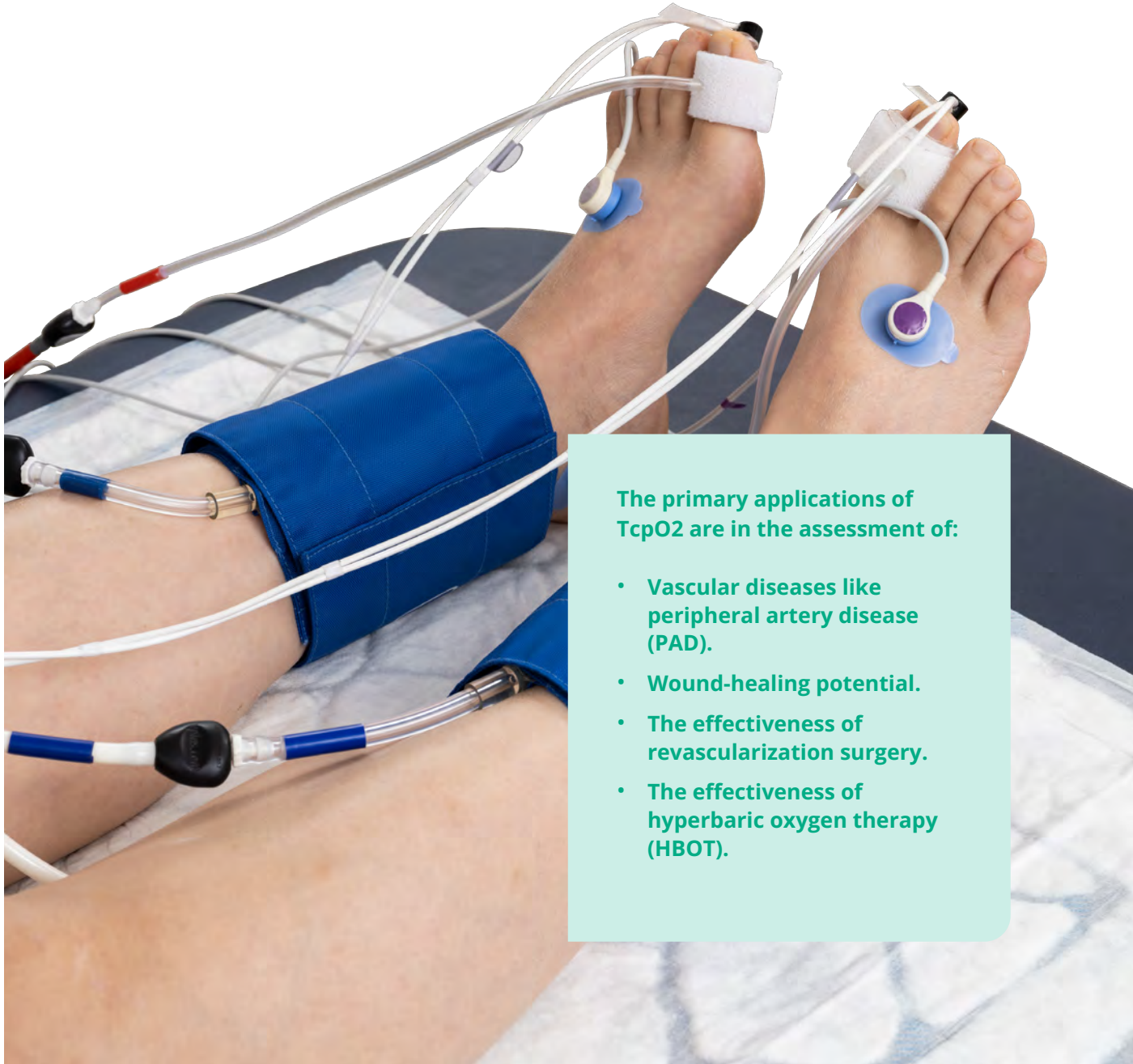

The primary applications of TcpO2 are in the assessment of:

- **Vascular diseases like peripheral artery disease (PAD).**
- **Wound-healing potential.**
- **The effectiveness of revascularization surgery.**
- **The effectiveness of hyperbaric oxygen therapy (HBOT).**

TcpO2 in practice

TcpO2 is made possible through Clark-type electrodes that can accurately measure the pressure of oxygen released through the skin. A self-adhesive fixation ring holds the electrode in place throughout measurement. The ring provides an airtight seal, and a few drops of contact liquid ensure a good connection between the electrode and the skin. The electrodes heat the skin to increase blood flow at the site. Typically, it takes about 15 minutes for the body to reach a stable maximum level of oxygen diffusion — producing a reliable TcpO2 baseline measurement in millimeters of mercury (mmHg).

One recent study [8] suggests that angiosome-guided (see Appendix B) TcpO2 contributes to a prognosis of successful foot ulcer healing. Comparing TcpO2 measurements in areas adjacent to a non-healing ulcer, for example, with measurements from additional sites can reveal microcirculatory deficiencies.

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According to the Global Vascular Guidelines [9], wound complications increase as TcpO2 levels fall below 40 mmHg.

It's possible to measure TcpO2 on a patient while they are undergoing hyperbaric oxygen therapy (HBOT), which is a useful way of determining the applicability of such treatment. If the in-chamber TcpO2 value is greater than 200 mmHg, the patient will likely benefit, but if it's less than 100 mmHg, HBOT is considered ineffective [5].

People with critical limb ischemia will almost always produce TcpO2 values below 30 mmHg and usually less than 20 mmHg [5]. Edema, inflammation, or temporarily constricted blood vessels due to cold, dehydration, or pain can, however, result in low TcpO2 values. Interpretation of TcpO2 values should be made in the context of the patient's clinical history and condition at the time of testing.

Microvascular disease can also result in low TcpO2 values, as seen in patients with diabetes. Isolated low values in tissue at the edge of a wound (with normal distal values) can be caused by local constriction, inability to form new blood vessels, or some other process confined to the wound [5].

In addition to the baseline, TcpO2 with provocation provides more information about microcirculation status. Commonly used techniques include oxygen challenges and leg elevation/lowering.

Interpreting TcpO2 results

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Interpreting TcpO2 results

In an oxygen challenge, the patient breathes 100% oxygen through a non-rebreather mask (for example). According to Fife et al. [5], an oxygen challenge is the best way to determine whether low baseline TcpO2 values (under 30 mmHg) are due to macrovascular arterial disease, or a temporary diffusion barrier — such as edema or inflammation. Patients with a baseline TcpO2 below 30 mmHg and above 100 mmHg on 100% oxygen are likely to have adequate arterial inflow but a local barrier to oxygen diffusion. Values for TcpO2 with 100% oxygen below 30 mmHg are consistent with severe artery disease [5].

Leg elevations can be useful to assess the wound healing potential of patients with borderline TcpO2 values (20-40 mmHg) [10]. The patient's leg is raised to a 30° angle (by placing a wedge-shaped support or using the bed). The study [10] showed that leg elevation can reveal the macrocirculatory capacity to overcome the "uphill" challenge. Concluding that a TcpO2 value of up to 15mmHg below the baseline is normal, whereas greater drops are indicative of arterial deficiency.

"An oxygen challenge is the best way to determine whether low baseline TcpO2 values (under 30 mmHg) are due to macrovascular arterial disease [5]

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SPP or TcpO2 — complementary exams

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Table 1: Recommended test by scenario

Scenario	SPP	TcpO2
Qualifying patients for HBO therapy	-	✓
Assessment during HBO therapy	-	✓
Wound on sole of the foot	✓	-
Sensitive patients	-	✓
Edema	✓	*
Vascular calcification	✓	✓
Simultaneous measurement with ABI, TBI, or segmental pressure	-	✓
Wound on/near heel of the foot	✓	✓

**Possible with provocation*

To determine the best course of treatment and address the complexity posed by individuals with diseases like diabetes and PAD, modern guidelines [4] [9] [11] include recommendations for multiple macro- and microcirculation measurements. In isolation, ankle-brachial index (ABI), for example, is not a reliable measurement for patients with diabetes, as they are misleading in up to 50% of cases [12].

For vascular diseases, toe pressure, skin perfusion pressure (SPP), and transcutaneous oxygen pressure (TcpO2) are among the exams recommended for diagnosis, prognosis, treatment, and follow-up. Both SPP and TcpO2 are invaluable aids in the assessment of patients whose ankles are non-compressible or whose toes have been amputated [1] [6] [7].

While both protocols provide insight into the status of a person's microcirculatory system, the condition of the patient usually guides the choice of exam.

One machine delivering SPP and TcpO2

PeriFlux 6000

PeriFlux 6000 is the only solution on the market that enables clinicians to carry out both SPP and TcpO2 exams on the same system.

In addition to SPP and TcpO2 microcirculation exams, PeriFlux 6000 supports a comprehensive set of established clinical metrics for measuring macrocirculation including toe pressure and TBI, ankle pressure and ABI, pulse volume recording (PVR), and segmental pressure — delivering a comprehensive and objective overview of the patient's vascular status in a single visit.

PeriFlux 6000 comes in multiple configurations, delivered on-cart with an integrated PC to guide clinicians through each measurement. Our configurations are modular, so if you start with a pressure solution for SPP you can always add TcpO2 later (and vice versa). Our standard protocols are designed to adapt to the working practices of most clinics and departments, and customizations are available.

Features

- Supports simultaneous TcpO2 and macrocirculation pressure exams — helping to optimize time and resources.
- Comprehensive assessment capabilities — avoids the need for multiple patient visits as all measurements can be captured in one session and summarized in a report.
- The use of heated laser Doppler probes overcomes the measurement difficulties that arise when vessels that supply blood to the skin constrict in response to cold — delivering sensitive toe pressure values and reducing prep time by removing the need to warm the patient.
- Heated laser Doppler probes promote measurement reliability by warming the skin to a consistent level, lowering the variability caused by temperature.
- Versatile TcpO2 solution.
- EMR connectivity via DICOM/HL7 interface.
- Single-machine approach lowers learning and maintenance overheads.

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Conclusion

Skin perfusion pressure (SPP) and transcutaneous oxygen pressure (TcpO2) have evolved into valuable microcirculation measurements for use in the prognosis and treatment of individuals with conditions like diabetes and peripheral artery disease (PAD). These two metrics, along with a range of macrocirculation exams such as toe pressure and TBI, ankle pressure and ABI, and pulse volume recording (PVR) provide clinicians with a comprehensive understanding of the patient's vascular health, helping them in their treatment decisions.

> **"Provide clinicians with the freedom to choose the most appropriate measurement for each patient.**

Through clinical research and developments in technology such as laser Doppler, SPP has evolved into a noninvasive and easily accessible vascular exam, suitable for predicting wound healing. Likewise, TcpO2 has become a versatile technique supporting simultaneous measurements of the peripheral vascular system and is viable for sensitive patients.

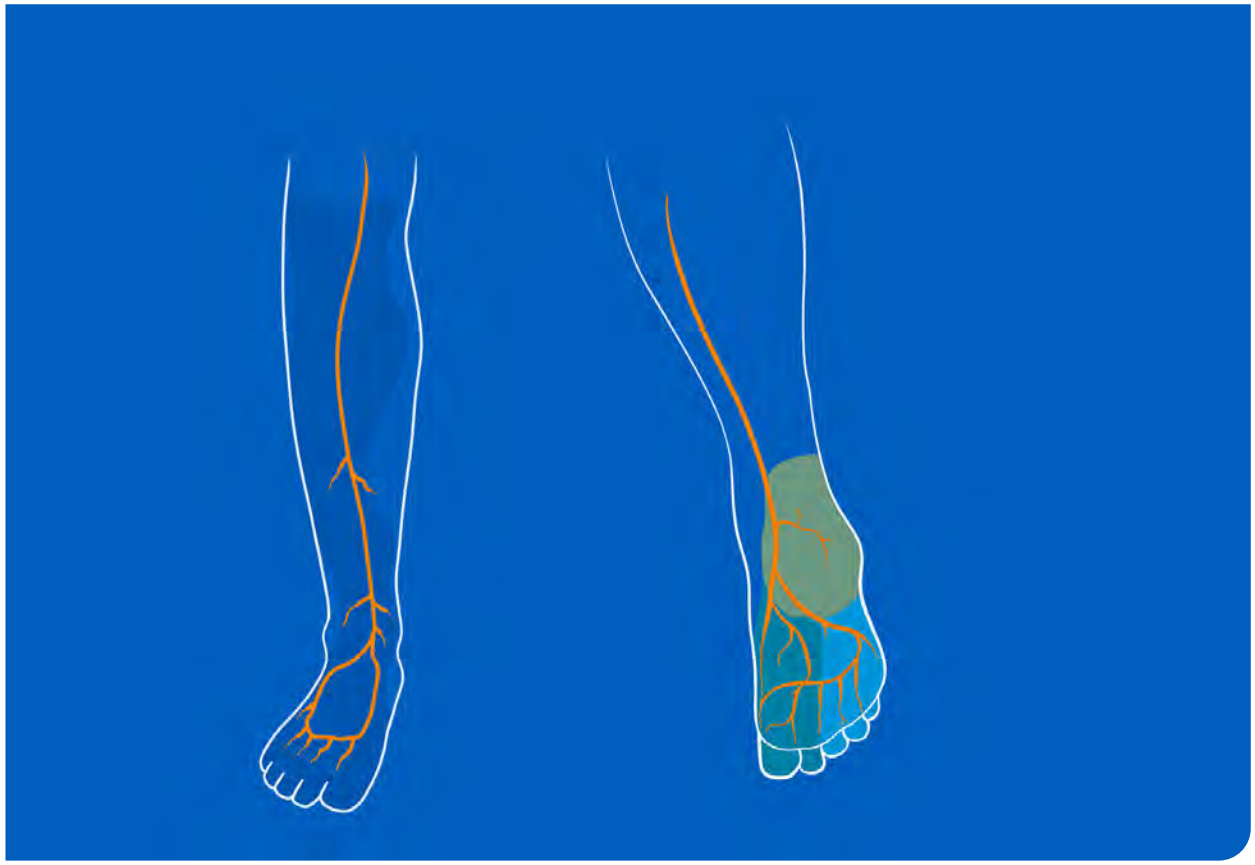
Healthcare professionals frequently ask us to explain the difference between SPP and TcpO2. From a technology perspective, SPP is a local microcirculatory blood pressure measurement, captured by laser Doppler whereas TcpO2 leverages Clark-type electrodes to measure the amount of oxygen released through the skin. They both measure microcirculation and deliver values that are measured objectively and systematically. The choice of SPP or TcpO2 primarily depends on the condition of the patient, complementing each other to provide options for most scenarios — illustrated in Table 1.

By supporting both SPP and TcpO2, PeriFlux 6000 is the only machine to deliver the microcirculatory tests recommended by international guidelines and **provide clinicians with the freedom to choose the most appropriate measurement for each patient**.

Appendix A — Abbreviations

Abbreviation	
ABI	ankle brachial index
DICOM	digital imaging and communications in medicine
EMR	electronic medical records
HIPAA	Health Insurance Portability and Accountability Act
HL7	health level 7
IWGDF	International Working Group on the Diabetic Foot
PAD	peripheral artery disease
PVR	pulse volume recording
SPP	skin perfusion pressure
TBI	toe brachial index
TcpO2	transcutaneous oxygen pressure

Appendix B
The angiosome concept



Angiosomes are an anatomical concept designed to explain the vascular supply in different areas of the human body. Angiosomes are distinct, three-dimensional blocks of tissue that are supplied by specific source arteries and drained by specific veins. The body can be divided into about 40 angiosomes, with six in the foot-ankle area, one fed by the anterior tibial artery, two by the peroneal, and three by the posterior tibial artery.

The concept is often used in plastic and reconstructive surgery and wound care. Non-healing wounds, such as diabetic foot ulcers, may be better understood by considering the vascular supply to the affected area. If the wound is within an angiosome with compromised blood flow, interventions like revascularization can be considered as a way to enhance wound healing.

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Appendix C — References

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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 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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