

Subdermal Temperature Measurement During Laser-Assisted Lipolysis: Proper Technique and Temperature Sensor Design

Cheryl Deguara, PhD and James L. Hobart, PhD.
Sciton, Inc., Palo Alto, California



Abstract

Maximizing patient outcomes, avoiding complications and increasing control of laser-assisted lipolysis procedures are all benefits that can be achieved with real time, subdermal, internal temperature measurement. Improper technique can obviate the benefits of internal temperature monitoring, thus proper use of internal temperature monitors must be employed. This paper highlights the proper technique for the use of subdermal, real-time temperature monitoring during laser-assisted lipolysis. In addition, an optimal design for the TempASSURE™ cannula and temperature sensor are described.

Background

Clinical observation and experimental evidence have demonstrated that spurious temperature measurements can result from incorrect use of subdermal, internal temperature monitoring for laser-assisted lipolysis. Understanding how anomalous temperature readings can occur is the key to understanding and performing proper technique and in assessing the optimal temperature sensor design.

The Basics of Internal Temperature Measurement

Subdermal, internal temperature monitors are designed to make real-time measurements while performing laser-assisted lipolysis. The temperature monitor is designed as follows: the temperature sensor is a thermocouple which is the junction of two dissimilar wires. The wires extend along the outside of the cannula to within a few millimeters of the end of the cannula at the point where the laser fiber exits the cannula and emits light, termed distal end (Figure 1).

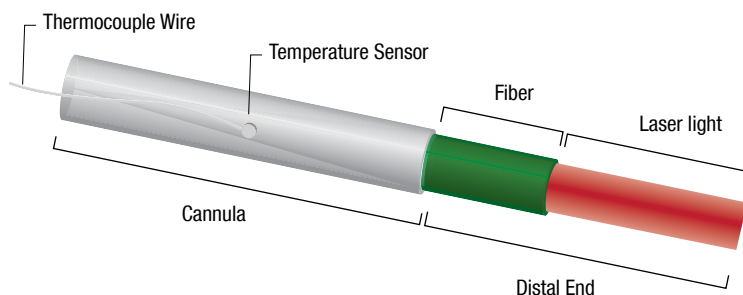


Figure 1: The distal end of a cannula with a temperature sensor.

A small amount of energy is scattered in all directions from the fiber tip. The amount of scattered light that is absorbed by the distal end of the cannula can vary and lead to unusually high temperature readings under certain conditions (Figures 2 and 4). Both temperature sensor design and technique can contribute to inaccurate temperature readings.

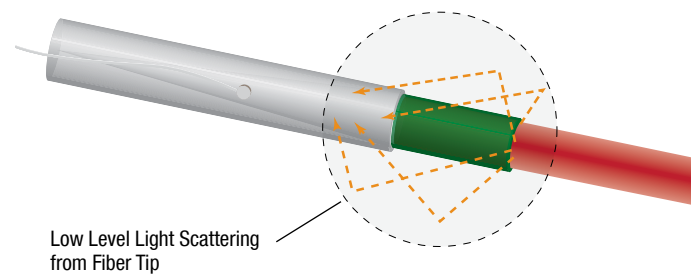


Figure 2: Scattering from the distal end can heat the cannula.

Improper techniques leading to this undesired heating effect include:

- 1) Inexact cleaving of the distal end of the fiber can increase the reflected laser power and consequent heating of the cannula.
- 2) Contamination of the tip can result in “hot tips” which can heat the cannula by creating a glowing carbonized material at the distal end.
- 3) The fiber tip is extremely close to the distal end of the cannula tip.
- 4) The laser is firing while the operator is moving too slowly, or not at all, in a medium conducive to back scatter.

A temperature sensor design-related condition leading to high heating of the cannula end occurs when the temperature sensor is an improper distance from the distal end of the cannula (Figure 4).

Each of these conditions leading to inaccurate temperature readings can be avoided by

- 1) using an optimally designed temperature sensor, and
- 2) following proper technique.

Proper Technique

Uncompromised Laser Fiber

It is highly recommended to use a new laser fiber for each case. However, many practitioners will reuse fibers from case to case. If the reused fiber is in excellent condition, the practitioner may not observe any problems. But if the reused fiber is compromised, this can result in increased backscatter and heating of the cannula.

A compromised tip will lead to increased backscatter because the distal end may become etched or even break during use. In contrast, when new, the distal end of the fiber has a polished, rounded orb tip. Practitioners should either replace the fiber (recommended) after use or cut the fiber with a special fiber cutting tool to reveal a clean, “new” tip. If this cut is improper, the

resulting backscatter can increase dramatically. Thus, it is critically important to know proper fiber cutting technique and how to adequately assess the quality of the cut. To avoid this all together, the most reliable and recommended method is to use a new fiber for each case.

Clean, Uncontaminated Fiber Tip

It is inevitable that there are situations when biological material may adhere to the distal end of the laser fiber and cannula. This material can become carbonized and create a “hot tip”. To avoid this complication, the practitioner should remove the cannula from the patient on occasion and monitor the tip. Any material stuck on the end should be gently wiped away with a sterile soft cloth. The cloth must be made of a material that does not also adhere to the cannula tip. If wiping with the cloth does not adequately remove the material, the practitioner should replace the fiber or re-cleave the tip as described above.

Proper Insertion of Fiber In Cannula

When inserting the fiber tip into the cannula, the practitioner is instructed to extend the fiber tip approximately 2 mm from the end of the cannula tip (Figure 3). Failure to adjust the fiber tip to the proper length from the cannula tip can increase the absorbed backscatter and consequently, heat the tip. To avoid this, take extra caution in adjusting the fiber tip, ensuring that it is at least 2 mm from the cannula tip. One must also be careful not to adjust the fiber tip greater than 2 mm from the cannula to avoid susceptibility to breakage during treatment. With a properly designed temperature sensor, the heating of the cannula tip and temperature sensor due to the distance of the fiber tip relative to the distal end of the cannula is mitigated (see next section). That said, it is still best practice to ensure the proper distance between the fiber and cannula end is maintained.

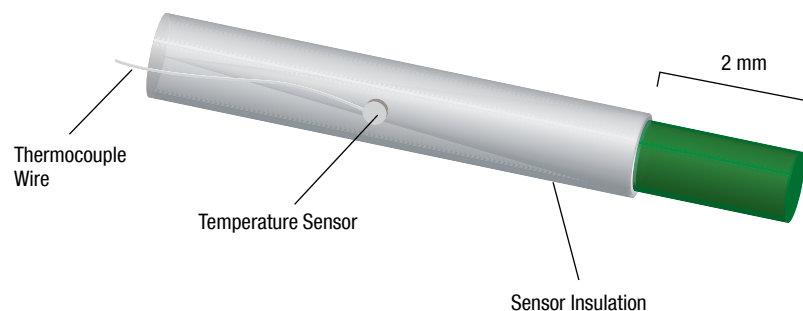


Figure 3: Proper distance of laser fiber to cannula is 2 mm.

Cannula Movement

The temperature of the cannula can be heated from backscatter, but the cannula will reach the tissue temperature in less than a second after the laser is no longer firing. The proper technique for temperature measurement is to release the footswitch, removing the source of heat, and stroke the cannula for a few seconds in the area to be measured. Theory and experiment both demonstrate that the temperature sensor, if heated to a higher temperature than the tissue, will return to the surrounding tissue temperature in less than a second (Appendix A).

The back scatter effect is greatest in certain tissues as the medium can impact the amount of light reflected onto and heating the temperature sensor. For example, in deep fatty layers, the reflected

light is essentially eliminated and the high temperature reading artifacts are negligible. However, in a situation where the cannula may be in an air pocket or moving through dense scar tissue, the temperature readings can spike due to the reflected light. The practitioner should pay close attention to the temperature as the laser is firing. When the temperature reading is within target or a few degrees higher, he should stop firing the laser, stroke the cannula a few seconds and note the temperature at this time. The temperature taken a few seconds after the laser has stopped firing is the correct temperature of the surrounding tissue. This practice will prevent aberrant temperature readings due to increased back scatter.

Optimal Placement of Temperature Sensor

A temperature sensor can also contribute to inaccurate and unusually high temperature readings that are not indicative of actual tissue temperature. Even when the practitioner uses ideal treatment technique, if the temperature sensor is not in the correct position on the cannula, the measurements will not reflect the tissue temperature accurately.

Under some circumstances, light, scattered from the output surface of the fiber tip of the laser, can reach the temperature sensor directly when it is located within a few millimeters of the distal end of the cannula. In this case the displayed temperature is higher than the bulk tissue temperature. The scattering effect is illustrated in Figure 4.

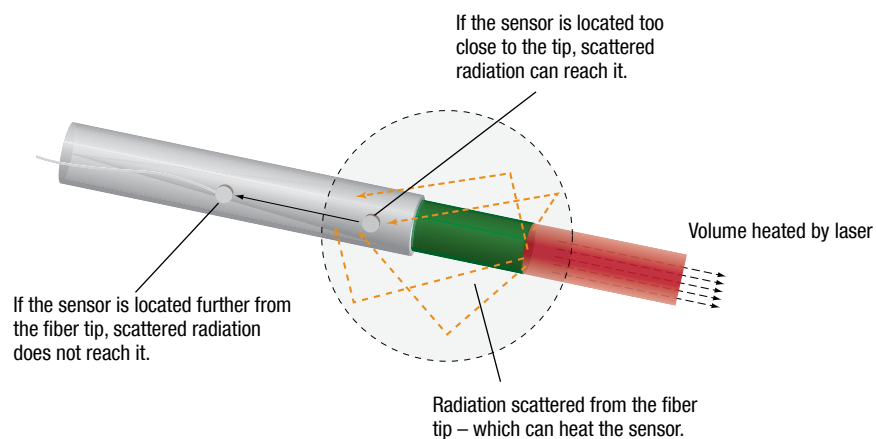


Figure 4: Proper placement of temperature sensor on cannula.

Laboratory tests and mathematical modeling identified the ideal distance of the temperature sensor from the cannula end. A laser fiber was fired in a human skin and fat tissue model through varying cannulas and temperature sensor configurations. A distance of 15 mm of the temperature sensor from the cannula end provided the ideal design for measuring surrounding tissue temperature. This distance maximizes the temperature sensor's ability to accurately measure tissue temperature while avoiding unusually high heating due to heating of the cannula from backscattered light when the temperature sensor is not used exactly as recommended.

Sciton® has introduced an improved TempASSURE model which minimizes this effect from

backscattered light by moving the temperature sensor further from the cannula end. The scattered light intensity at this position is greatly reduced, so that the sensor temperature is identical to the tissue temperature. The modified design is shown in Figure 4. The optimized design of Sciton's TempASSURE minimizes aberrant temperature readings, improving the physician's ability to safely and effectively provide the best clinical outcomes.

Summary

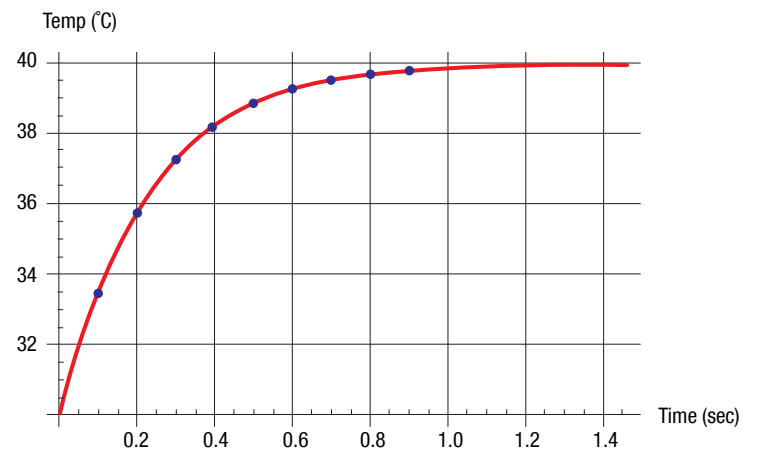
Proper technique and optimal temperature sensor design are necessary to achieve the maximum benefit that can be obtained from using internal temperature monitoring with laser-assisted lipolysis. Laboratory measurements and mathematical modeling have led to an optimized design of the TempASSURE from Sciton. Using new fibers for each case, cleaning the fiber properly during a treatment, adjusting the fiber to the proper distance from the cannula end, and taking temperature measurements both during and immediately after firing the laser are all best practices for ensuring correct temperature measurement of treated tissue. Following these simple guidelines and using the TempASSURE will provide the maximum level of safety and optimal patient outcomes.

Appendix A: Thermal Time Constant of the TempASSURE Cannula

The thermal time constant of a system is its thermal impedance times its heat capacity. The sensor insulator has a thermal impedance of 2.5 kelvin/watt. The sensor heat capacity is 0.09 joule/kelvin. The time constant is then 0.23 second. This is the time for the sensor to move two-thirds of the way to a new outside temperature.

To give a concrete example: Let the sensor be initially in a medium at 30 °C. It is then quickly moved into a new position in the medium where the temperature is 40 °C. The sensor reading versus time would be:

Time (sec)	Temp (°C)
0.0	30.0
0.2	35.8
0.4	38.2
0.6	39.3
0.8	39.7
1.0	39.9



Appendix B

TempASSURE Specifications

Temperature Range	4 °C to 70 °C
Temperature Accuracy	± 1 °C
Measurements (LxWxH)	92 mm x 150 mm x 28 mm
Monitor Type	LCD 4.3 inch, 480 x 272 pixel (WQVGA)
Power Source	Rechargeable Lithium-ion Battery
Cannula Length	150 mm, 200 mm, 250 mm





925 Commercial Street, Palo Alto, California 94303
Phone: 888 646 6999 • Email: info@sciton.com
www.sciton.com

©2011 Sciton, Inc. All rights reserved. Sciton is a registered trademark and TempASSURE is
a trademark of Sciton, Inc.

2600-003-07 Rev A