In vivo monitoring of laser tattoo removal using pulsed photothermal radiometry and diffuse reflectance spectroscopy

Golmajer Zima N[(1)], Verdel N[(1)], Lukač M[(1,2)], Majaron B[(1,3)*]

(1) Department of Complex Matter, Jožef Stefan Institute, Ljubljana, Slovenia
(2) Fotona, d.o.o., Ljubljana, Slovenia
(3) Faculty of Mathematics and Physics, University of Ljubljana, Slovenia

*Corresponding author's email: neza.golmajer-zima@ijs.si

Background and Methods – We present an innovative attempt to noninvasively characterize black tattoos in a human volunteer and objectively monitor the effectiveness of laser tattoo removal treatment. To that end, we have adapted a recently introduced methodology for assessment of the structure and composition of human skin *in vivo* by combining two optical techniques [1,2]. The approach combines pulsed photothermal radiometry (PPTR), involving time-resolved measurements of mid-infrared emission with a fast infrared camera (FLIR Systems SC7500) after irradiation with a millisecond laser pulse at 532 nm, and diffuse reflectance spectroscopy (DRS) in visible part of the spectrum (λ = 400–650 nm). Both data sets are fitted simultaneously with the respective predictions of a numerical model of light- and heat transport in human skin (with or without the tattoo) [3]. In intact skin, this approach allows assessment of the contents of specific chromophores (e.g., melanin, oxy- and deoxy-hemoglobin) as well as scattering properties and thicknesses of the epidermis and dermis [1,2].

In present study, four test sites in a homogeneous black tattoo of a healthy volunteer were treated using a medical-grade laser instrument (StarWalker® MaQX by Fotona d.o.o., Slovenia; λ = 1064 nm) with radiant exposures of 1.5, 3.0, 4.5, and 6.0 J/cm^2, respectively.

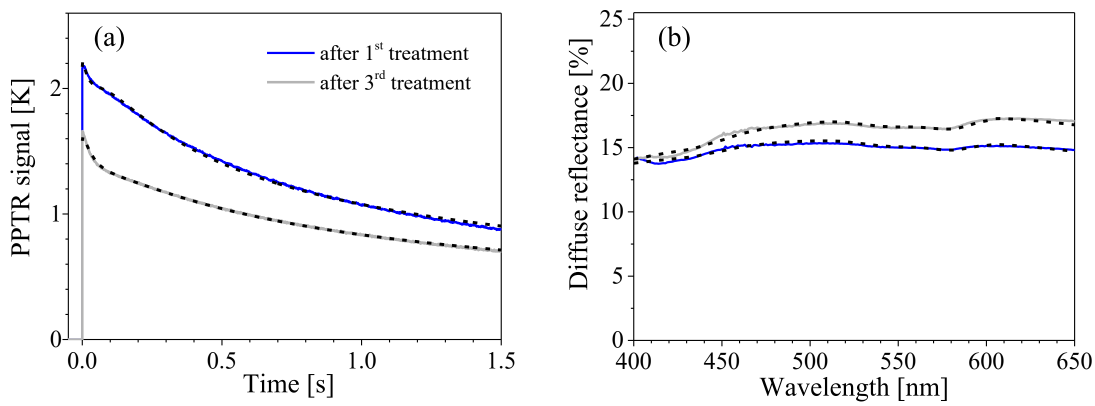

Fig. 1. (a) PPTR signals and **(b)** DRS spectra as measured in a black tattoo in human skin in vivo after the first (blue solid lines) and third laser treatment (grey) at radiant exposure of 6 J/cm^2. The dashed lines are best fitting predictions from our numerical model, based on a 3-layer optical model of the tattooed skin.

Results and Discussion – The results of our analyses (Fig. 2a) reveal a significant reduction of the tattoo ink content after both first and second treatment in the test site irradiated with 6 J/cm^2, but only after the second one at 4.5 J/cm^2. In contrast, the decrease of the ink content is only marginal in the site treated with 3 J/cm^2, and insignificant at 1.5 J/cm^2. In addition, the results also indicate a gradually increasing depth of the tattoo ink layer with the applied radiant exposure and number of treatments.

Both results match very with the visual inspection of the test sites, which demonstrates a good sensitivity and robustness of our approach. Moreover, the presented technique provides an objective assessment of the treatment success, even in the cases where the effect may be difficult to see with a naked eye.

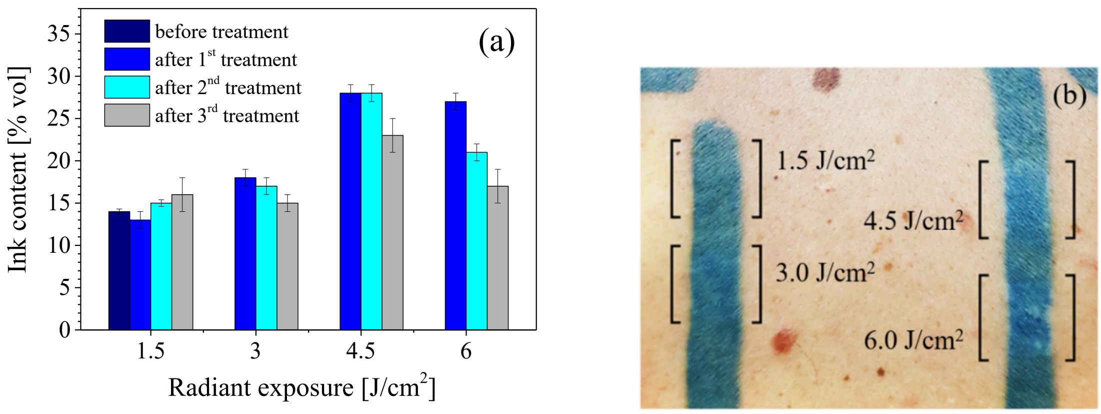

Fig. 2. (a) The assessed contents of the tattoo ink in dermis over the course of three laser treatment sessions. **(b)** Photograph of the four test sites several weeks after the second laser treatment, with the applied radiant exposure values.

Acknowledgments – This research was supported by the Slovenian Research Agency (grants P1-0192 and PR-10471). The authors thank Fotona, d.o.o. (Ljubljana, Slovenia) for the loan of medical-grade laser used for PPTR measurements (DualisVP), and for performing the tattoo removal treatments.

References

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