Experimental Phantom Verification Studies for Simulations of Light Interactions with Skin

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Abstract: Raytracing computer models are valuable tools to determine the fluence at a specific depth into tissue, but need to be verified before they can be used with confidence. Such a model for skin showed good agreement (within 10%) when compared with images from experiments on solid resin skin simulation phantoms.

1. Introduction

The interaction of laser light with human tissue is an area of continuous research due to non-invasive light based techniques gaining momentum as diagnostic and treatment modalities [1]. Computer models simulating, *in vivo* conditions, can be an invaluable tool to determine the laser power or fluence at specific depths into the tissue for optimum dosage requirements. In order to use such a model with confidence, it needs to be verified with experimental results. The aim of this study was to determine the agreement between the results predicted by the computer model and the experimental measurements done on skin simulating solid resin phantoms.

2. Methods

ASAP software from Breault Research was used as raytracing software to trace photons through a layered structure representing skin. In order to verify the model a two layered phantom (simulating the epidermis and dermis in the skin) was constructed from resin [2]. The diameter of the phantom was 3 cm and the thickness varied from 2-5 mm, depending on the sample. The optical properties of the different layers of the phantoms were measured with an Integrating Sphere and used as input for the raytracing model to determine the fluence. The fluence distribution, calculated at the back of the model was compared with the experimentally measured fluence, using a CCD camera, focused at the back of the phantom. A HeNe laser (λ= 632.8 nm) was used for the experimental work and the optical properties used in the model were also calculated at a wavelength of 632 nm. For the work to be relevant to the South African society, phantoms representing the different skin tones present in South Africa, were manufactured.

3. Results

Images from the CCD camera (fluence distribution) compared favorably with the fluence distribution calculated with the model. In Figure 1 the raytracing model and CCD images for the same sample are compared. Although the fluence distribution in the two images is similar, the absolute values of the total laser power exiting the model differs. There was a good correlation between the simulated and experimentally determined fluence distribution. The discrepancies in the absolute values between the computer model and the experimental measurements may be attributed to the inaccuracies (± 4%) in determining the optical properties of the different layers in the phantom.

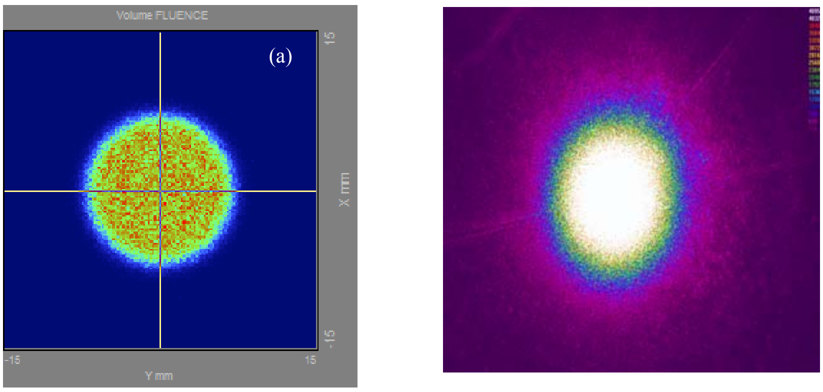

Figure 1: Comparison between computer generated results (a) and CCD images (b) of the laser beam after passing through the phantom. Phantom diameter was 30 mm in both cases.

4. References

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