QIRT10 http://dx.doi.org/10.21611/qirt.2010.113
10th International Conference on Quantitative InfraRed Thermography
July 27-30, 2010, Québec (Canada)

Infrared monitoring of laser-tissue interaction for dermatological applications

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Abstract

One of the medical field in which laser action has been successfully employed is dermatology [1, 2]. Diseases like skin melanoms and angioma are usually treated with laser therapy. In this field, during the last decades, technology supplied laser sources with technical properties specifically designed in order to accomplish the specific requirements of several application. Nowadays dermatologists can rely on a wide range of lasers which vary in wavelengths (some of them out of the visible range) and thus they can be selectively employed according to the specific application and type of pathology. The activity of the doctor consists in applying in the area of interest of the skin of the patient the laser light for a specific time and a fixed intensity. After it he verifies the effects induced by the light laser after one or two weeks time. The doctor usually makes use of the laser on his patient in an empirical way. Basically, just starting from his own experience he decides the duration of the application and the intensity of laser light on the skin according to some parameters such as the individual patient, the pathology and the skin phototype. In most of the treatments what happens is that the doctor has no possibility of directly evaluating the effect of the laser applied on line since the wavelength of it is not in the visible range or is pulsed. This means flashes of few milliseconds too fast to be recorded by the eyes. This limits the job of the doctor since the beam power chosen might be too low or too high on one side or the duration of the pulse too short or too long respectively. This seems to be the only significant limit in the application of laser in dermatology. It is important to underline that sometimes the doctor has to work under a safe regime for the patient. This means that he has to avoid damages like burns which might occur since he has no direct vision of the interaction light-treated tissues and so he prefers working with a lower intensity of light. This aspect, on one side means a safer situation for the patient but on the other side minimize the efficacy of the therapy making the cure time longer. The possibility to give to the doctor a tool which makes him able to monitor on-line the reaction of the skin during the laser application and to dose, after a preliminary check, the laser parameter according to the phototype under treatment, means to enhance the performances of the light effect enlarging remarkably the application fields and optimizing the action itself in terms of both efficiency and curing times. In this view thermography seem to be the best solution. In this contest we studied the possibility to employ a thermal camera, supported by a specific software for IR imaging, in order to monitor the laser-tissue interaction [3-5]. The idea was to supply the dermatologists with a tool for valuating in real time the action of a laser beam on human tissue and, after the elaboration of the input parameters related to the treated patient, to optimize the involved light in terms of power intensity and time of exposure of the beam.

In order to test the validity of the software, which we elaborated, and the effectiveness of on-line infrared monitoring, we organised clinical trials at the Dermatological Department of the II Policlinic of "Federico II" Naples University. In particular we applied our new methodological approach to study the laser-biological tissue interaction on patients affected by Plane Angioma pathology, known as Port Wine Stain (PWS) pathology. This pathology is a vascular malformation that consists in a blood vessels accumulation under the tissue. This accumulation forms a subsurface *plane of vessels* of depth and thickness depending to the specific anatomic region and, in general, is different from case to case. The main problems in the cure of Plane Angioma with laser therapy are:

- ü the therapeutic efficiency can be different from patient to patient. It general it depends on the age, anatomic region, phototype, lesion depth and lesion thickness.
- ü possible formation of scars
- ü possible formation of dischromic area.

In the laser treatments of patients affected by PWS the therapeutic program and laser parameters are chosen following general tables and indications present in literature. In table we report the reference ranges for laser parameters suggested for the therapy of PWS.

Table 1. *Laser parameters for Plane Angioma treatments*

Wavelength	585-595 nm
Energy density	4-10 J/cm^2
Pulse duration	1-5 ms
Spot diameter	2-7 mm

During the laser exposure, we monitored the thermal reaction of the tissue under laser action. The first data were elaborated by a numerical simulation, in order to obtain information about the specific plane of vessels under treatment. This tool allows to give to the doctor the right laser parameters to employ according to the type of the patient under treatment.

We will show the numerical simulation with the flow chart running for laser parameters to choose in order to obtain the best results. Furthermore, we will present also the experimental results of the clinic tests done on thirty patients affected by PWS and report the contribute of our new methodological approach, based on IR imaging, aimed to the optimization of laser therapy employed for the considered pathology. We believe that, owing to our new methodological approach, the laser therapy will guaranty better performances in the treatments, a higher level of efficiency, shorter application times, more safety for the patient and less money for the end user. Finally, we think that the suggested method, thanks to the encouraged results, could be extended also to others pathologies in medical field.

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