A study of dosimetry for Near-InfraRed radiation

Gastone CASTELLANI1, Daniel REMONDINI1, Lorenzo DARPE3, Paolo MONDARDINI2

1Physics Dept. Bologna University, Viale B. Pichat 6/2, 40127 Bologna IT
gastone.castellani@unibo.it
2Medicine Faculty. Bologna University, Via Massarenti 9, 40127 Bologna IT
3Department of Veterinary Clinical Sciences, Padova University Agripolis-viale dell’Università 16 35020 Legnaro (Padova) IT

Abstract: We show preliminary results of a dosimetric study of Near-InfraRed (NIR) radiation onto human skin and related underlying tissues (muscle, bone). Starting from data extracted literature (obtained both from simulations and real experiments) it is possible to define a function for calculating the ratio of energy reaching a specified tissue depth, once the adsorption coefficients have been introduced.

Keywords: dosimetry, near-infrared radiation, laser therapy, complex interaction with tissues.

Introduction

Dosimetry in biological tissues is a topic that still raises interest, since new applications of electromagnetic fields of different frequency are nowadays designed. Recently many laser therapies are under study, given the potential therapeutic effect onto joints and tendons after a lesion or a shock. As a first step, in order to reproduce experimentally such effects onto in vivo cultures, it is necessary to correctly estimate the effective dose reaching the inner tissues, since the skin and the muscle can largely attenuate the incoming radiation.

Motivation

The purpose of this work is to obtain a quantitative characterization of the inner radiation doses penetrating human tissues, starting from the parameters available in literature for the various components (e.g. skin, muscle, bone). This will allow to calibrate in vitro irradiation experiments starting from the doses applied externally in typical therapeutical protocols involving such instruments (i.e. NIR lasers).

Methods

We collected informations about adsorption spectra and reflectance coefficients from different literature sources [1-4], and on the basis of these data we constructed a formula for dose estimation, that can provide a range of values depending on the depth of the different crossed tissues, and on the specific parameters considered (e.g. the colour of the skin).
**Results**

Since the intensity decay of electromagnetic radiation in the Non Ionizing region of the spectrum can be well described by an exponential function (as stated by the Lambert-Beer law [5]), and we have a different contribution depending on the crossed tissue and its depth, we consider an exponential function with the sum of the contribution from the different tissues, as given by the adsorption coefficient $\mu$, the tissue thickness $l$ and the average (effective) skin reflectance $R$ (see figure).

$$I(x) = I_0 \cdot R \cdot \exp^{-\sum \mu_i \cdot l_i}$$

Where $I(x)$ is the resulting intensity on the target (i.e. cartilage or tendon) after crossing the tissue and $I_0$ is the incident intensity of radiation (as generated by the source) on the skin.

The result can be adapted to different configurations (e.g. knee, shoulder, neck) in which the tissues can be found in different ratios.

*Simplified scheme of the tissutal compartments crossed by NIR radiation*

**Conclusions**

Starting from literature, we collected informations about adsorption coefficients of several tissues (from skin to bone) that could be crossed by a NIR radiation, and built a formula that can evaluate the effective dose reaching a specific target (e.g. a joint cartilage or tendon). This will allow to estimate effective doses applied during in vivo therapeutic protocols, and the relative doses to be applied during in vitro experiments onto cell cultures. Moreover this knowledge on dose distribution in biological tissues will allow to optimize the parameters commonly used in therapeutic protocols for rehabilitation purposes with NIR laser instruments.

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References


