Evaluation of red light scattering in gingival tissue – in vivo study

Leticia Heineck Alvarenga\textsuperscript{a,b,⁎}, Martha Simões Ribeiro\textsuperscript{c}, Ilka Tiemy Kato\textsuperscript{d}, Silvia Cristina Núñez\textsuperscript{e}, Renato Araujo Prates\textsuperscript{a,b,⁎}

\textsuperscript{a} Department of Biophotonics, Universidade Nove de Julho (UNINOVE), São Paulo, Brazil
\textsuperscript{b} School of Dentistry, Universidade Nove de Julho (UNINOVE), São Paulo, Brazil
\textsuperscript{c} Center for Lasers and Applications - IPEN-CNEN/SP, São Paulo, Brazil
\textsuperscript{d} Department of Biomedical Engineering, ABC Federal University (UFABC), São Bernardo do Campo, SP, Brazil
\textsuperscript{e} Department of Bioengineering, Universidade Brasil, São Bernardo do Campo, Brazil

\textbf{A R T I C L E  I N F O}

\textbf{Keywords:}
Photodynamic therapy
Dosimetry
Red laser
Light scattering
Low-level laser therapy

\textbf{A B S T R A C T}

Antimicrobial photodynamic therapy (aPDT) has been used to treat periodontal disease, thus the aim of this study was to investigate red light (\(\lambda = 660\) nm) attenuation in gingival tissue. This clinical trial included 30 patients with chronic periodontitis; three incisors from each patient were selected for the experimental procedures. A laser source with a radiant power output of 100 mW was used. Two digital photographs were taken of each selected incisor (in frontal and occlusal position). The images were analyzed in the \textit{ImageJ} program. The results demonstrated that at a 3 mm distance from the laser probe, there is an attenuation of light intensity of 50%, along frontal and occlusal views. Light attenuation in gingival tissue should be considered when setting optimal parameters for antimicrobial photodynamic therapy or photobiomodulation.

\section{1. Introduction}

Lasers have many applications in Periodontology including root surface decontamination; soft tissue excision, incision and ablation; and calculus removal. The use of photobiomodulation (PBM) therapy has been proposed as an adjuvant treatment for periodontal disease [1], and the lack of consistency within the literature, this clinical study was carried out to investigate the red light (\(\lambda = 660\) nm) attenuation in gingival tissue.
2. Materials and methods

This clinical trial was registered on ClinicalTrials.gov (NCT 03262077) and it involved 30 patients with chronic periodontitis. The patients were recruited from the Dental Clinic of Nove de Julho University (UNINOVE, Brazil). The project was approved by the Human Research Ethics Committee of the University (number 1.517.902). Patients who agreed to participate signed a statement of informed consent approved by the Research Ethics Committee from the same university.

Patients were included based on the following criteria: aged 18 years or older with chronic periodontitis [19], presence of at least 15 teeth and at least 3 incisors with probing depth greater than 4 mm [20,21]. The patients selected were receiving periodontal treatment at the university’s dental clinic.

2.1. Photographs

Each patient had 3 incisors selected for the procedure. Two digital photographs were taken of each selected incisor - one in a frontal position (Fig. 1A) and one in an occlusal position (Fig. 1B). A Rebel T2i camera (Canon, Japan) with 100 mm macro lens was used and the following parameters were adopted for all photographs: 35 mm focal length, f/22 aperture, 1/100 shutter speed and ISO 200. While the photographs were being taken, each selected incisor received irradiation, from a laser source with radiation emission at wavelength of 660 nm and radiant power output of 100 mW. The images were recorded for analysis in the ImageJ program.

3. Results

During the analysis of the frontal photographs, we observed light intensity zones around the laser probe indicating that light was scattering diffusively in the gingival tissue (Fig. 2). In the image the zones of scattered light with a circular shape suggested that light intensity decreases from the center to the peripheral zone.

Using the images of scattered light captured by the camera, it was possible to extract the intensity variation using the Image J program. The results showed that at a 3 mm distance from the laser probe, there is an attenuation of light intensity of 50%, along frontal and occlusal views (Fig. 5). Due to the similar behavior of light attenuation, we observed that the light scattered in all directions in the same manner.

4. Conclusion

Photobiomodulation therapy has several applications in the area of Dentistry and it has been used to accelerate healing, bone repair, reduction of hypersensitivity, reduction of inflammation, pain relief and to provide other benefits as well [22,23]. The effects of PBM are caused by photochemical reactions within cell compounds, resulting in activation of cell proliferation, mitochondrial respiration, and collagen and ATP synthesis. In the process of periodontal repair, the effects of PBM encourage faster wound healing, when compared to conventional mechanical therapy. There are several studies which look at the effects of PBM on wound healing. Ustaoglu et al. investigated the effect of PBM after gingival surgery. The Ga-Al-As laser was used on wounds in an experimental group receiving doses of 8.6 J/cm², with an irradiation time of 8 s and a constant output power of 3 W in continuous-wave mode (CW). The handpiece was positioned at a distance of 1 mm above the wound area, perpendicularly, in noncontact mode and the area of the probe was wider than that of the wound. The authors concluded that PBM had a positive effect on human palatal donor site healing after a gingival graft [24].

Another use for lasers is the reduction of the microbial load in periodontal pockets; this is done via antimicrobial photodynamic therapy (aPDT). However, the results of the studies, concerning this use, are inconsistent as to whether there exists an improved outcome when using aPDT to reduce subgingival bacteria [25]. Campanile et al.


