

Basic Research Proves Efficiency of Magnetic and Laser Field Combination in Phototherapy.

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Introduction.

One of the basic mechanisms of photo-bio-modulation is the acceleration of electron transfer by electromagnetic radiation in the visible and near infra-red region of the spectrum [1,2]. In the presence of an electron acceptor such as molecular oxygen (O_2), electron transfer reduces O_2 to the super-oxide anion O_2^- , which subsequently dismutates into hydrogen peroxide (H_2O_2) [3]. Both O_2^- and H_2O_2 are highly reactive oxygen species (ROS). Acceleration of electron transfer also increases adenosine triphosphate (ATP) production by the respiratory chain in the mitochondria via the reduction of O_2 to water [1,2]. ATP is the fuel that drives protein production and hence cell proliferation and regulates ion transport via the cell membranes. As a result of electron transfer, the redox state of the cell is displaced to a more oxidized redox state.

We have shown that molecular oxygen can be replaced by 2,2,6,6-tetramethyl piperidine-N-oxyl (TEMPO) [4]. TEMPO is a stable free radical, which can readily accept an electron or react with an unstable free radical, thereby losing its free radical, paramagnetic character. This leads to a very sensitive method for measuring electron transfer and free radical production by the observation of the decay of the EPR (electron paramagnetic resonance) signal of TEMPO. In a previous experiment [4], we have shown that red-light illumination of cell samples during 5 minutes with an energy dose of 150 J/cm^2 and an intensity of 500 mW/cm^2 produced a reduction of about 20% in the TEMPO EPR signal. It is worthwhile noting that the intensity of the red light used in this experiment was about five times the maximum solar intensity near the equator. In the next section, we shall see how the synergy of a magnetic field of about 35 mT with a pulsed infrared laser with a very low average intensity, together with red and infrared light emitting diodes (LEDs) with a total average intensity of about 50 mW/cm^2 produces the same TEMPO EPR signal reduction as in the previous experiment although the intensity and the energy dose were about ten times lower.

Materials and methods.

We examined three “TerraQuant Solo Lasers” devices of “Multi Radiance Medical”: (a) pulsed red LEDs (5 Hz, 10 mW/cm^2 , 635nm) + pulsed infrared LEDs (5 Hz, 40 mW/cm^2 , 875nm) + short (100ns) infrared laser pulses (5Hz, peak intensity: $15,000 \text{ mW}$, $0.4\text{-}1.4 \text{ mW/cm}^2$, 905nm) + permanent magnet (35 mT); (b) pulsed LEDs + infrared laser pulses; (c) pulsed LEDs + permanent magnet. We measured the modification of the cellular redox state

following 5 minutes irradiation with these three devices by monitoring the decay of the characteristic triplet EPR signal of the stable TEMPO radical. Four TEMPO EPR measurements were performed with device (b) and (c) and six measurements with device (a). The decay of the TEMPO EPR signal is ascribed to the reduction of TEMPO to an EPR silent hydroxylamine [5].

The TEMPO EPR measurements were carried out by adding 10 μ L of a 0.2 mM solution of TEMPO to 90 μ L of cell solution. The sample was then drawn into a gas-permeable Teflon capillary (Zeus, NJ) and inserted into a quartz tube. The tube was placed in the cavity of Bruker EPR 100d X-band spectrometer and measured at the frequency 9.74 GHz. TEMPO spectra were measured with scan width 50G.

Results.

Unlike the high intensity experiments described in [4], the experiment with the device (b), at an average intensity lower by one order of magnitude yielded no observable decay of the TEMPO EPR signal, as expected. The addition of the permanent magnet to the LEDs in device (c) did not produce any observable reduction in the TEMPO EPR signal, either. Only with device (a), where the permanent magnet and the pulsed infrared laser were simultaneously present was a $21.8 \pm 2\%$ reduction in the TEMPO EPR signal observed (see Fig.1).

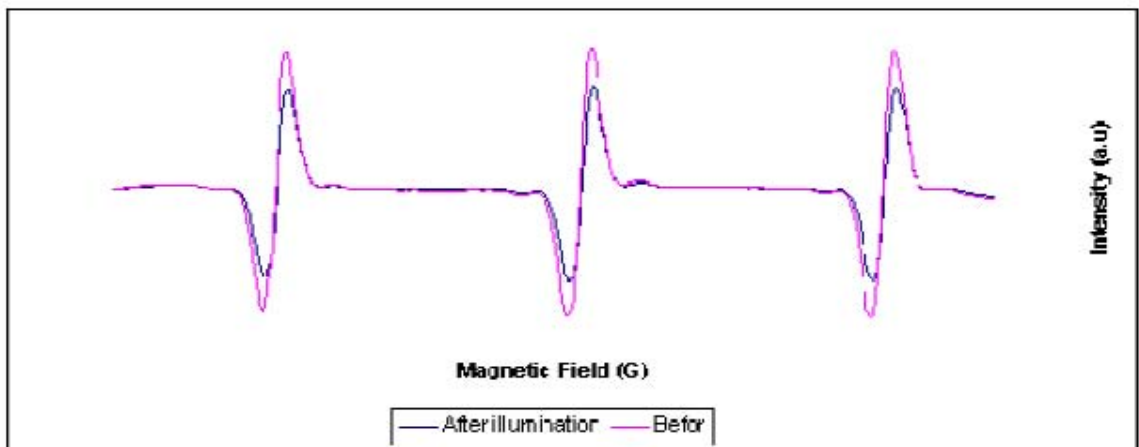


Fig.1. EPR spectrum monitoring shows 21.8% TEMPO signal reduction following 5 minute illumination of cell solution with device (a).

Conclusion.

The bio-photochemical effect of the “TQ Solo Laser” devices of “Multi Radiance Medical” is due to the remarkable synergy between a laser of very low average intensity, mild LED radiation and a low-intensity magnetic field. None of the separate components has shown any effect at all.

The fact that this remarkable synergy enhances electron transfer has important consequences as discussed in the Introduction. One of these consequences, the activation of the respiratory chain accompanied by enhanced ATP production and cell proliferation, shows that “TQ Solo Laser” may improve wound healing by accelerating the replacement of damaged cells. It may also reduce pain in auto-immune diseases, which is due to the aggressive effect of the ROS produced by the immune system. Here electron transfer plays an antioxidant role, neutralizing the ROS [3].

References.

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