Debate Continues Regarding LED Therapy with Continuous Wave Versus Pulsed Output

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The debate regarding the use of so-called pulsing versus continuous wave (CW) in the clinical and research applications of low incident light therapy has been continuing since the advent of low energy level laser therapy systems (as distinct from those used in laser surgery) in the early 1980's. It might be useful, however, before starting to examine the various ideas behind these two methods of delivering phototherapy to tissue either *in vivo* or *in vitro*.

Continuous wave is very simply that: when a light source is switched on, the output power almost instantaneously reaches its maximum or preset level,

The results suggest very strongly that a CW beam induced fibroblast cell growth, and hence possibly collagen production.

and remains there until the system is switched off, whereupon the output power falls almost instantaneously to zero (Figure 1a). An electronic or mechanical shutter can be placed in the beam bath, the purpose of which is to chop or gate the CW beam into a series of square waveforms of light, between which is an interval when the light is 'off' (Figure 1b). This is not, however, pulsing the beam, but is simply switching the beam on and off at predetermined frequencies (the number of times the beam is switched on in one second) with a predetermined on-off duty cycle.

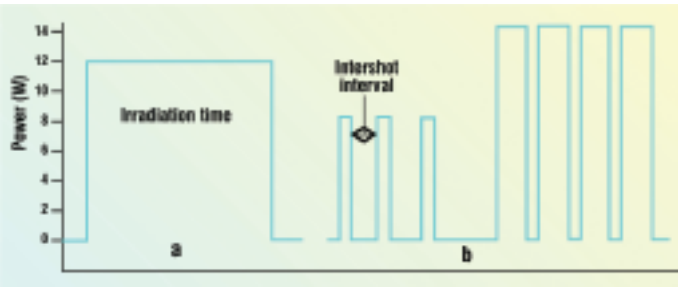

Figure 1a and 1b

Rather than pulsing, this should be referred to as frequency modulation as it is imposing an artificial frequency on the existing frequency inherent to the wavelength of the phototherapy system, since wavelength and frequency are linked inversely. A true pulsed beam, on the other hand, usually has a high peak power, with a short pulse width of 1 ms or less (Figure 1c).

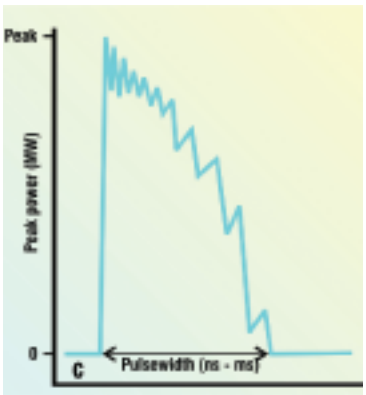

Figure 1c

When laser therapy was popularized in the late 1980s, one of the main and best reported applications was pain attenuation. Pain is transmitted via the appropriate neurons which communicate one with the other via synapses. If one considers that the synaptic cleft is only operative for tiny fractions of a second, during which the polarization of the cleft enables the neurotransmitters such as acetylcholine to jump the gap between the neuropod and the receptor, it then follows that a continuous wave beam, rather than a gated beam which has comparatively long periods when it is off, will have a much greater chance of depolarizing the synapse at the critical moment, so that the neurotransmitter fails to reach the receptors, and the pain is blocked.

Some interesting theories have been suggested regarding the effects of frequency modulating therapeutic beams so as to have an effect on the target cells, by which they are induced to vibrate in harmony with the incident light, thereby increasing the action spectrum of the cell. I would invite the readers to consider the following experiments, which were designed and performed by Luciana Almeida-Lopes, D.D.S., Ph.D., a well experienced dental laser researcher from São Paulo, Brazil, whose findings and illustrations I would here like to acknowledge.

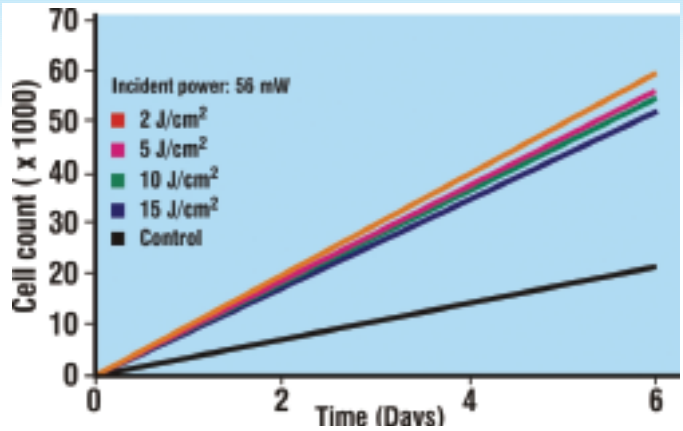

Figure 2

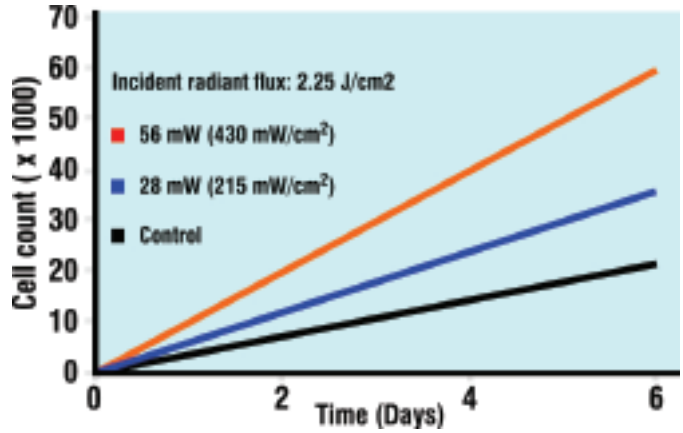

Figure 3

She and her colleagues wanted to elucidate an ideal phototherapeutic dose, to examine how best to deliver that dose, and then to examine the effect of frequency modulating the light versus continuous wave on first generation human gingival fibroblasts *in vitro*, rather than using a commercially available cell line. The wavelength used was 644 nm, and the laser system delivered either 56 mW or 28 mW over a 4 mm diameter spot, giving incident power densities of 430 mW/cm² or 215 mW/cm², respectively.

In the first experiment, using the 56 mW output power, the cells were irradiated at doses of approximately 2.25, 5.5, 11 and 16.5 J/cm², with an unirradiated control group handled in exactly the same way as the experimental groups. Cell growth was assessed daily up to six days. All experiments were repeated 3 times and the results averaged. As can be seen from Figure 2, the 2.25 J/cm² dose produced the greatest number of cells after six days, but in fact all of the doses used induced cell growth which was statistically significantly better than the unirradiated control.

Having elucidated 2.25 J/cm² as the optimum dose, the next experiment examined how altering the irradiance while keeping the dose constant would change the result. There were three groups of cells: one unirradiated control, one irradiated with 56 mW and one with 28 mW, changing the irradiation time to maintain the dose constant at 2.25 J/cm².

Figure 3 shows that the 56 mW irradiated cells increased in number significantly better than the 28 mW group and the unirradiated controls. In other words the higher power density for the shorter period of time stimulated cell growth better than the lower power density and longer irradiation time.

Finally, various beam frequencies (10, 60, 120 and 180 Hz) at 56 mW and 2.25 J/cm² were compared with unirradiated controls and a CW irradiated group. As can be seen from Figure 4, the CW irradiated cells grew significantly better than the frequency modulated groups, but higher frequencies tended to produce better cell growth than lower frequencies, though the differences were not significant.

This last experiment showed quite clearly that, for first generation cultured fibroblasts and at the parameters used in this study, CW irradiation induced significantly better cell growth *in vitro* after six days than did any of the frequency modulated beams. Naturally, this was an *in vitro* experiment, and how the results can be interpreted or extrapolated into an *in vivo* situation remains to be proved in further experiments. But the results suggest very strongly that a CW beam induces fibroblast cell growth, and hence collagen production, better than so-called pulsed beams. ■

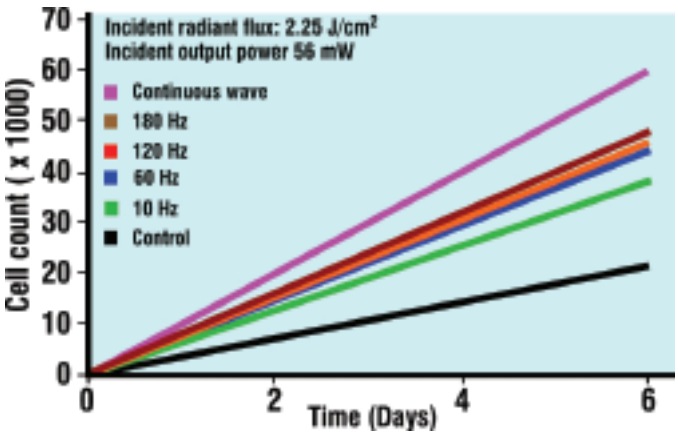

Figure 4