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Clinical

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Accelerated Implant Stability After LED Photobiomodulation

ABSTRACT

Previous studies have demonstrated more rapid dental implant integration as a result of the biostimulatory effect of laser and light emitting diode (LED) photobiomodulation in both in vitro and in vivo models. It was the purpose of this clinical trial to examine the effect of the extra-oral application of LED treatment on implant stability, as assessed by resonance frequency analysis (RFA).

35 patients had 63 dental implants placed in either the maxilla or mandible. 23 patients had an OsseoPulse LED device (Biolux Research Ltd, Canada) positioned over the surgical site by the patient and utilized on a daily basis of 20 mW/cm2 for 20 min at a wavelength of 618 nm for 21 days. All implants were were tested for primary stability with an Osstell Mentor RFA device (Osstell AB, Sweden) at the time of implant placement, and at 14, 30, 60 and 90 days.

Patients treated with the LED device demonstrated significantly ($p<0.05$) improved dental implant stability at day 14, day 30 and day 60. No significant differences were seen at the time of implant placement or at day 90.

The results have demonstrated that the LED photobiomodulation accelerated implant stability as compared to the untreated dental implants in this investigation. These results may suggest that LED photobiomodulation may allow for more rapid integration of dental implants.

KEYWORDS: implant stability, LED, photobiomodulation, resonance frequency analysis

INTRODUCTION

Laser and light emitting diode (LED) photobiomodulation has been shown to stimulate the intracellular production of ATP, particularly in cells that are ischemic or wounded (Hawkins and Abrahamse, 2006). Cells present in wounded tissue or adjacent to osteotomy sites are typically ischemic due to lack of vascularization in the initial stages of wound repair.

One of the mechanisms thought to be responsible for this increase ATP production is the absorption of laser and LED photons by the respiratory chain enzyme Cytochrome c oxidase (Eells et al, 2005). The absorption of photons is thought to cause a conformational change in the enzyme which pumps protons from the cytoplasm to the intra-membrane space of the mitochondria (Kaila, 2008). This increased proton pumping and consequent increased proton concentration and electrical gradient causes ATP to be produced through protons passing through ATPase enzyme back into the cytoplasmic space (Gressler, 1982). This increase in intra-cellular ATP allows for more normal cellular function in cells that are metabolically sub-optimal. This creates an environment which encourages faster wound healing (Wong-Riley et al, 2005).

Previous studies have demonstrated more rapid achievement of dental implant stability as a result of the biostimulatory effect of laser photobiomodulation in animal models (Khadra et al 2004). A previous clinical investigation using light emitting diode (LED) photobiomodulation demonstrated an increase in the rate of dental implant stability as measured using resonance frequency analysis compared to unstimulated control implants (Brawn et al, 2007).

OBJECTIVES

The purpose of this clinical investigation was to examine the effect of the extra-oral application of LED treatment on implant stability as assessed by resonance frequency analysis (RFA).

MATERIAL AND METHODS

35 patients having had 63 dental implants placed were examined. Nobel Biocare Replace Select Tapered or Biohorizon Internal implants were placed, using the manufacturer's guidelines to ensure standardized placement, in 3 centres across Canada.

The patients were divided into two groups: Group 1 (n=23, 40 implants) received daily LED treatment according to the treatment protocol described below using the OsseoPulse device (Biolux Research Ltd, Canada) after implant placement **(Figure 1)**.

Group 2 (n=12, 23 implants) served as the untreated controls receiving no postoperative LED treatment after dental implant placement.

The LED device consisted of an adjustable headset which could be customized to the patient's face and head. Stability and repeatable positioning was achieved by ensuring three point contacts on the ears and bridge of the nose. This integrated alignment system allowed the dentist to position the LED treatment array over the surgical site on the surface of the cheek, ensuring a repeatable positioning by the patient for at-home treatment. The device produced continuous wave spectrum with a peak at 605-631nm.

The integrated controller allowed the dentist-operator to prescribe the 21 day treatment and monitor its progress. The clinician would adjust, align and fixate the extra-oral LED array **(Figure 2)** on the cheek surface overlying the surgical site and the patient was instructed in its use. The patient then activated the LED device at home on a daily basis as prescribed.

For the patients in Group 1 the LED device was applied with an energy density of 20mW/cm^2 per treatment of 20 minutes over a period of 21 consecutive days directly over the surgical area. The implants in both groups were tested for primary implant stability with an Osstell Mentor (Osstell AB, Sweden) RFA device at the time of placement and at 14, 30, 60 and 90 days.

Implant stability was measured by using the RFA device together with the wireless SmartPeg attached to the implant **(Figure 3)**. The technique was utilized without contact and was non-invasive. The RFA device created a variable frequency magnetic pulse and measured the resonance frequency of vibration of the implant to arrive at the ISQ-value, which was indicative of primary implant stability. ISQ is scaled from 1 to 100; the higher the ISQ value, the more stable the implant (Sul et al, 2002).

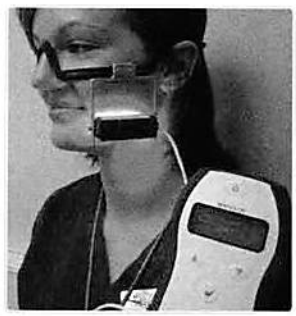

Figure 1. The OsseoPulse device consists of programmable controller and adjustable extra-oral heaset and array.

Figure 2. The OsseoPulse array aligned over the surgical site.

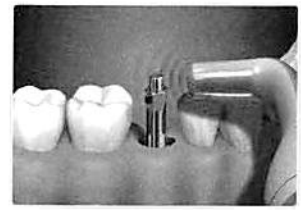

Figure 3. Implant stability is measured by using the Osstell Mentor together with the wireless Smartpeg attached to the implant.

RESULTS

The implants in Group 1, the LED treated implants, demonstrated a mean ISQ at Day 0 = 67.83, Day 14 = 66.99, Day 30 = 70.03, Day 60 =72.85, Day 90= 73.77.

For the implants in Group 2 the implants demonstrated a mean ISQ at Day 0 = 72.59, Day 14 = 62.31, Day 30 = 63.57, Day 60 = 68.51, Day 90= 72.05.

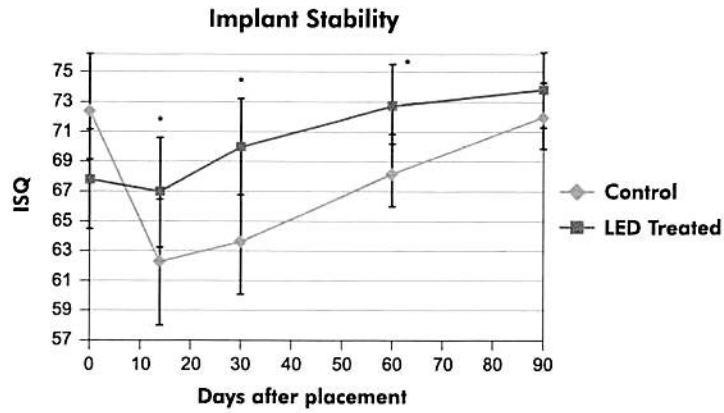

Figure 4. Mean ISQ Stability for both LED implants in Group 1 (LED treated) and Group 2 (untreated).

As number of studies have indicated that an ISQ of 65 - 69 or more corresponds to stability sufficient to load an implant with final restorations (Glauser et al, 2004 and Cornelini et al 2006), we assessed the net acceleration of implant stability over time by looking at the stability data using threshold ISQ levels of 65, 68 and 70.

Patients treated with the LED device (Group 1) demonstrated significantly ($p<0.05$) improved dental implant stability at day 14, day 30, day 60. No significant differences were seen at the time of implant placement or at day 90.

Utilizing an ISQ stability threshold of 70, implants in Group 2 (untreated) achieved this stability in a mean of 72.5 days, whereas Group 1 implants (LED treated) achieved stability in a mean of 29.9 days. This represents a reduction in time to implant stability of 58.8% when compared to untreated implants.

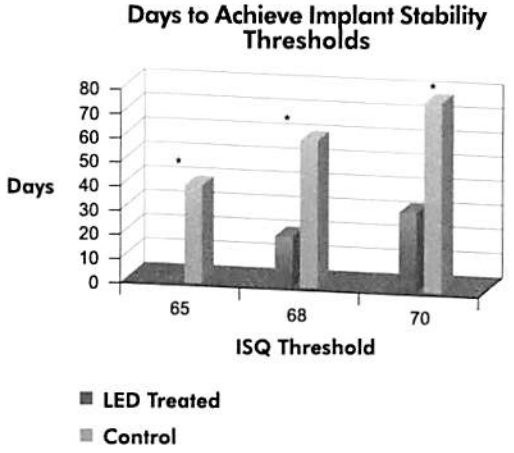

Figure 5. Demonstrates the mean number of days required implants in Group 1 (LED treated) and Group 2 (untreated) to achieve threshold ISQ stability.

DISCUSSION

The results of this investigation have demonstrated that the implants that were LED treated had greater significantly stability than the untreated control implants at 14, 30 and 60 days post implant placement. By day 90 no differences were identified. These results reflect the expectation that by 90 days the bone-implant interface remodeling process is near completion. The differences seen at earlier time points suggest that the LED treated implants actually become more stable faster. It may be that the normal sequence of initial resorption next to the surface of the implant followed by new bone deposition may be improved. Typically during the initial resorptive phase we seen a decrease in implant stability over the first two weeks followed by an increase in stability (Frieberg et al, 1999).

This is not seen when LED treatment is applied after placement. This may reflect the fact that this initial resorption phase may be eliminated, and implants may achieved greater stability sooner.

These results are consistent with research showing an increase in retention of laser treated implants in the rabbit model (Khadra et al 2004) and from the implant study which demonstrated the acceleration of stability of LED treated implants compared to controls. (Brawn et al, 2007) The implications of these findings may be that the use of LED treatment to dental implants may predictably allow for earlier loading of dental implants.

CONCLUSIONS

The results of this investigation demonstrated that the LED treated implants may achieve stability earlier as compared to the untreated dental implants in this investigation. These results may suggest that LED treatment may allow for more rapid implant integration and therefore allow for earlier loading of dental implants.

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