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# Measurement of effective remnant power in low intensity laser after passage through the buccinator muscle in anatomical human hemifaces

## *Determinação da potência efetiva remanescente após a passagem do laser de baixa intensidade através do músculo bucinador em peças anatômicas/hemifaces*

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### Abstract

**Objective:** To determine the effective remnant power after the passage of low intensity laser of two different wavelengths (660 and 780 nm) through buccinator muscle in anatomical hemifaces. **Methods:** Five human hemifaces were dissected, and a laser was shone in the central region of the muscle with a receiver placed on the opposite side. The hemifaces were irradiated using the same dosimetric parameters (40 mW, 1 W/cm<sup>2</sup>, continuous mode, 0.04 cm<sup>2</sup>) and at the same point in every muscle; remnant power was measured for each irradiation. **Results:** The average remnant power after irradiation with 660 nm (149 ± 15 µW) light was significantly lower (p<0.0001) than with that of 780 nm (380 ± 40 µW). **Conclusion:** The LIL of 780 nm presented greater remnant power in comparison to the 660 nm laser after passage through the buccinator muscle, indicating the latter's greater penetration capacity.

**Key words:** Facial muscles; Laser therapy, low-level; Myofascial pain syndromes.

### Resumo

**Objetivo:** Determinar a potência remanescente após a passagem do laser de baixa intensidade em dois comprimentos de onda (660 e 780 nm) através do músculo bucinador em peças anatômicas dissecadas. **Métodos:** Dissecaram-se cinco hemifaces humanas expondo o músculo bucinador. Aplicou-se o laser na região central de cada músculo, e o receptor, para aferir a potência remanescente, foi posicionado na superfície intraoral contrária. As hemifaces foram irradiadas nos mesmos parâmetros dosimétricos (40 mW, 1 W/cm<sup>2</sup>, modo contínuo, 0,04 cm<sup>2</sup>) e no mesmo ponto em cada músculo, sendo a potência remanescente aferida a cada repetição. **Resultados:** A potência média restante após as irradiações de 660 nm (149 ± 15 µW) foi menor (p < 0,0001) que com as irradiações de 780 nm (380 ± 40 µW). **Conclusão:** O LBI de 780 nm apresentou maior potência remanescente que o LBI de 660 nm, após passagem pelo músculo bucinador, denotando sua maior capacidade de penetração.

**Descritor:** Músculos faciais; Síndromes da dor miofascial; Terapia a laser de baixa potência.

## Introduction

Temporomandibular disorders (TMD) is a multifactorial<sup>1</sup> syndrome that has a prevalence of 40% to 75%<sup>2</sup> and comprises a heterogeneous group of disorders. Its diagnosis was standardized into three categories (Research Diagnostic Criteria for Temporomandibular Disorders – RDC / TMD)<sup>3</sup>: myofascial TMD, TMD with disc displacement, and other joint conditions (arthralgias, arthritis, arthrosis). Myofascial TMD is the most common among them, causing pain and impairment of masticatory function<sup>4,5</sup>. Although the masseter and temporalis muscles are involved more in myofascial pain, trigger points were reported in the buccinator muscle<sup>6</sup> and in the anatomical area of this muscle<sup>7,8</sup>.

Low intensity laser (LIL) has been increasingly used in dentistry in recent years<sup>9,10</sup>, and it is currently regarded as an important therapeutic option for the treatment of temporomandibular disorders (TMD)<sup>5</sup> and for myofascial pain<sup>11,12</sup>. LIL has been extensively studied because it is non-pharmacological, non-invasive, and does not cause adverse effects<sup>4,13</sup>. Its mechanism of action is not completely understood, but there are reports of improved blood supply and muscle oxygenation and re-balance of pH, promoting analgesia and muscle relaxation<sup>14-17</sup>. However, although some authors have obtained good results<sup>4,5</sup>, the heterogeneity of laser therapy parameters<sup>18-20</sup> limits its use as a treatment modality for myofascial pain<sup>11,12</sup>. Thus, more studies are needed to evaluate dosimetric parameters (wavelength, dose, power) and tissue optical properties<sup>14</sup>.

There is a misconception that longer wavelengths are always therapeutically more effective<sup>21</sup>. When the laser beam reaches the biological tissue, a portion is absorbed, another portion is reflected, and yet another one dissipated. The absorbed light produces the desired effect, and its simple penetration to deep tissue levels might not produce the required effect<sup>22</sup>. Therefore, it is important to understand the be-

havior of light in different tissues, and create laser therapy protocols.

The aim of this study was to determine the effective remnant power after the passage of low intensity laser light of two different wavelengths (660 and 780 nm) through buccinator muscle in anatomical specimens.

## Material and methods

This project was approved by the Research Ethics Committee of Nove de Julho University (Approval # 69642 in 08/08/2012).

Five human hemifaces (from the morphology laboratory of Nove de Julho University – UNINOVE, Anatomy Laboratory of the Vergueiro Unit) were used; they were dissected to fully expose the masseter muscle (skin and jugal mucosa removed.) Specimens were fixed following the Giacomini simplified protocol with some adaptations<sup>23</sup>. In this technique, formaldehyde is used for a short period of time and a glycerin protocol is executed. Specimens were fixed in 10% formaldehyde, resting fully immersed for seven days; after this period, they were dissected. After dissection, the formaldehyde was removed, and the specimens were conserved in glycerin. The hemifaces were placed in sequentially increasing concentrations of alcohol (50%, 60%, 70%, 80, 90%, and absolute), resting for 24 hours in each dilution. After dehydration the pieces were immersed in glycerin for 15 days, after which they were removed and left at room temperature in inclined position in order for the excess glycerin to drain until they became dry. The use of 10% formaldehyde could cause specimens to darken, but with the glycerin technique and a brief exposure, the darkening is not so intense, and the natural color is preserved. Since the viscosity of glycerin can influence the results, the excess was removed and the pieces were completely dried to minimize bias. This technique maintains the stained muscles closer to their natural state<sup>24,25</sup>.

The skin of the buccal mucosa that covers the buccinator muscle was removed, and speci-

mens were selected in which the buccinator muscle was most preserved and the direction of its anteroposterior fibers was clearly visible. Selected specimens had their mouth slightly open or had no premolars and molars in order to allow intraoral receptor positioning without interference from the teeth. The laser was applied in the central region of the muscle (considering upper-lower and anteroposterior directions) and a power sensor (area 2.84 cm<sup>2</sup>, Coherent Inc, Portland, Oregon, USA) was positioned exactly at the opposite point, at the intraoral surface of the irradiated muscle, in order to measure the remnant power after passing through the muscle tissue.

Irradiations were performed with infrared (780 nm) and red (660 nm) lasers both with output power of 40 mW (output power density of 1 W/cm<sup>2</sup>, cw-mode, beam area of 0.04 cm<sup>2</sup>, MM Optics Twin Laser, Sao Paulo, SP, Brazil). The laser beam was positioned perpendicularly and in close contact with the surface of each muscle, in order to minimize light reflection. Ten measurements were made with each laser. All measurements were performed in a dark room to avoid interference from other light sources.

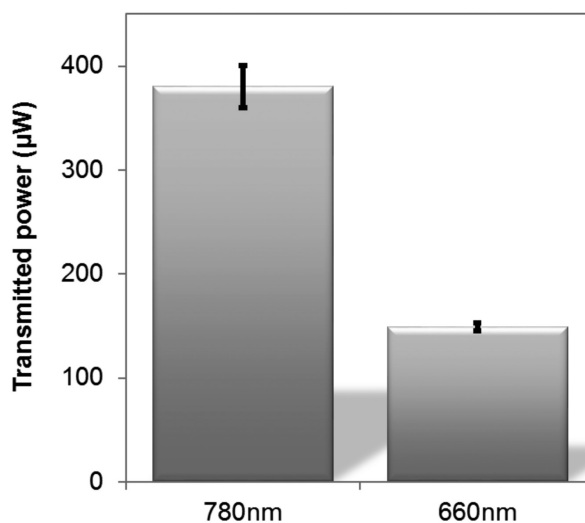
The Liliefors test was used to test the normality of the data. The test-t (Bioestat 5.3, Brazil) was used to compare results. They were expressed as mean  $\pm$  SD.

## Results

The average remnant power after passage of 660 nm LIL through muscle tissue was 149  $\mu$ W ( $\pm$  15  $\mu$ W). The average for 780 nm LIL was 380  $\mu$ W (40  $\pm$   $\mu$ W). The difference between groups was statistically significant ( $p < 0.0001$ ), using the test-t for parametric data.

## Discussion and conclusion

In recent years, there has been increasing interest in the effects of LIL used in different medical specialties as a single therapy, rather



**Figure 1:** Graph of mean and standard deviation of the remnant energy in groups of 780nm (40mW) and 660nm (40mW) through buccinator \* ( $p < 0.0001$ ). nm = nanometer,  $\mu$ W = microwatt

than merely a complementary one<sup>26</sup>. The therapeutic LIL wavelengths are in a range between red and infrared (600-1070 nm), where 780-950 nm wavelengths generally penetrate deeper and are used to treat deeper layers of tissue, and those between 600 and 700 nm are used to treat superficial tissues<sup>17</sup>. Different wavelengths such as 808 nm GaAs<sup>27</sup>, 830 nm GaAs<sup>28</sup>, 904 nm<sup>29</sup>, 780 nm<sup>30</sup> GaAs, 890 nm GaAs, 660 nm In-Ga-Al-P<sup>1</sup>, 830-904 nm, and Ga-Al-As<sup>29</sup> have been used for the treatment of muscle pain and temporomandibular dysfunction. Red and infrared lasers are often used as therapeutic options for myofascial pain<sup>11,12,31</sup>.

In this study, it has been found that 780 nm laser yields a greater remnant power of LIL after passing through the buccinator muscle than 660 nm laser. We observed that 0.95% (i.e. 380  $\mu$ W) of the total irradiated light (40 mW = 40,000  $\mu$ W) with the wavelength of 780 nm was effectively transmitted through the buccinator muscles. These results do not mean that the remnant light (99.05% – 39,620  $\mu$ W) has been fully absorbed. It is known that part is reflected before reaching the target tissue. To minimize this bias, the laser remained in direct contact

with the anatomical specimen during application because power loss is lower under this condition<sup>21</sup>. With the 660 nm laser, 0.37% (i.e., 149  $\mu$ W) of the total irradiated light (39,851  $\mu$ W) was effectively transmitted through the buccinator muscles. Thus, we could indirectly infer that the wavelength of 660 nm transmitted less power than the 780 nm wavelength. It can be stated that more than half of the transmitted light was lost with the use of the 660 nm laser, when compared with the 780 nm one.

These results corroborate the statement that this wavelength is more suitable for deep tissue use<sup>21</sup>, unlike the buccinator muscle, which has slight thickness ( $\pm 3$  mm.); therefore, shorter wavelengths may be more effective for superficial tissues.

Obviously, the results of this study should be validated *in vivo*. It is known that living tissue is subject to variations of different parameters, such as blood supply, liquid content, amount of collagen, and muscular thickness<sup>32</sup>. They may also vary depending on the individual, irradiated location, color of skin, and age. Therefore, for this study, anatomical hemifaces of male adults were used, with similar thickness and absence of skin and connective tissue.

Finally, longevity of the treatment will not be attained if myofascial pain has an occlusal origin. If the dentist fails to restore the occlusal balance (through occlusal splints, orthodontic treatment, or selective grinding) that causes muscle imbalance, the temporary analgesia caused by LIL may be interpreted as treatment failure, because the source of the problem has not been addressed<sup>13</sup>. Therefore, for lasers to be recognized as a treatment method, it is necessary to better understand the optimal parameters of LIL<sup>17</sup>. Based on the results obtained in this study, it can be concluded that 780 nm LIL yields more remnant power than 660 nm lasers after passing through the buccinator muscle. For superficial tissues, we could infer that red lasers may promote more laser-tissue interaction and be more suitable.

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