DOI:10.5585/ConsSaude.v14n2.5516 Recebido em 3 mar. 2015 / aprovado em 13 jun. 2015

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

Emilly Cruz Pinto Reuter[1]; Monalisa Jacob Giuselini[2]; Anna Carolina Ratto Tempestini Horliana[3,4]; Tatiana Dias Schalch[3,5]; Marcelo Betti Mascaro[3]; Alessandro Melo Deana[4]; Raquel Agnelli Mesquita Ferrari[4,6,7]; Sandra Kalil Bussadori[3,5,6]; Kristianne Porta Santos Fernandes[3,5]

[1] Graduate Student, School of Dentistry – Universidade Nove de Julho – Uninove. Sao Paulo, SP – Brazil.
[2] Master Degree Student, Biophotonics Applied to Health Sciences Post Graduation Program – Universidade Nove de Julho - UNINOVE São Paulo Brazil.
[3] PhD, Professor, School of Dentistry – Universidade Nove de Julho – Uninove. Sao Paulo, SP – Brazil.
[4] PhD Professor, Biophotonics Applied to Health Sciences Post Graduation Program - Universidade Nove de Julho – UNINOVE São Paulo Brazil.
[5] PhD Student, Biophotonics Applied to Health Sciences Post Graduation Program – Universidade Nove de Julho – UNINOVE.
[6] PhD Professor, Rehabilitation Sciences Post Graduation Program - Universidade Nove de Julho - UNINOVE. Sao Paulo, SP – Brazil.
[7] PhD, professor, Physical Therapy School - Universidade Nove de Julho – UNINOVE São Paulo Brazil.

Postal address
Anna Carolina Ratto Tempestini Horliana
Av. Vergueiro, 235/249
01504-001– São Paulo – SP [Brasil]
annacrth@gmail.com

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^2, continuous mode, 0.04 cm^2) 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^2, modo contínuo, 0,04 cm^2) 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[1] syndrome that has a prevalence of 40% to 75%[2] and comprises a heterogeneous group of disorders. Its diagnosis was standardized into three categories (Research Diagnostic Criteria for Temporomandibular Disorders – RDC / TMD)[3]: 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[4,5]. Although the masseter and temporalis muscles are involved more in myofascial pain, trigger points were reported in the buccinator muscle[6] and in the anatomical area of this muscle[7,8].

Low intensity laser (LIL) has been increasingly used in dentistry in recent years[9,10], and it is currently regarded as an important therapeutic option for the treatment of temporomandibular disorders (TMD)[5] and for myofascial pain[11,12]. LIL has been extensively studied because it is non-pharmacological, non-invasive, and does not cause adverse effects[4,13]. 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[14-17]. However, although some authors have obtained good results[4,5], the heterogeneity of laser therapy parameters[18-20] limits its use as a treatment modality for myofascial pain[11,12]. Thus, more studies are needed to evaluate dosimetric parameters (wavelength, dose, power) and tissue optical properties[14].

There is a misconception that longer wavelengths are always therapeutically more effective[21]. 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[22]. Therefore, it is important to understand the behavior 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[23]. 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[24,25].

The skin of the buccal mucosa that covers the buccinator muscle was removed, and specimens 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 anteriorposterior directions) and a power sensor (area 2.84 cm^2, 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^2, cw-mode, beam area of 0.04 cm^2, 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 ± SD.

Results

The average remnant power after passage of 660 nm LIL through muscle tissue was 149μW (± 15 μW). The average for 780 nm LIL was 380 μW (40 ± μW). 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

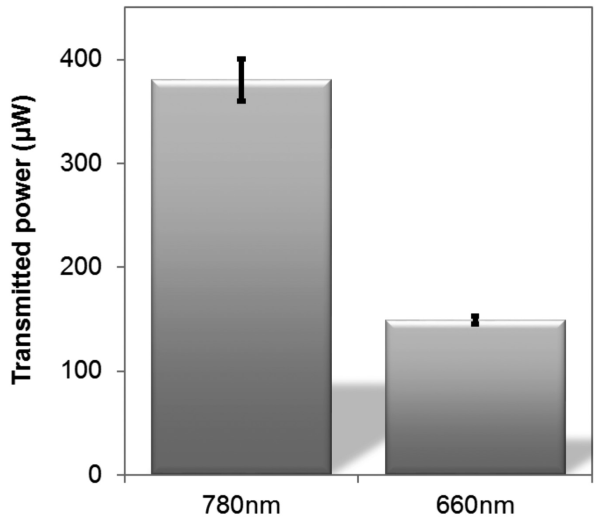

Figure 1: Graph of mean and standard deviation of the remnant energy in groups of 780nm (40mW) and 660nm (40mW) through buccinator * (p <0.0001). nm = nanometer, μW = microwatt

than merely a complementary one[26]. 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[17]. Different wavelengths such as 808 nm GaAs[27], 830 nm GaAs[28], 904 nm[29], 780 nm[30] GaAs, 890 nm GaAs, 660 nm In-Ga-Al-P[1], 830-904 nm, and Ga-Al-As[29] 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[11,12,31].

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 μW) of the total irradiated light (40 mW = 40,000 μW) 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 μW) 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[21]. With the 660 nm laser, 0.37% (i.e., 149 µW) of the total irradiated light (39,851 µW) 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[21], unlike the buccinator muscle, which has slight thickness (± 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[32]. 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[13]. Therefore, for lasers to be recognized as a treatment method, it is necessary to better understand the optimal parameters of LIL[17]. 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.

Acknowledgments

KPS Fernandes, SK Bussadori and RA Mesquita Ferrari were supported by National Council for Technological and Scientific Development (CNPq, grant nº 303662/2012-3, nº 305905/2014-7 and nº 305739/2014-0 respectively).

References

1. Shirani AM, Gutknecht N, Taghizadeh M, Mir M. Low-level laser therapy and myofascial pain dysfunction syndrome: a randomized controlled clinical trial. Lasers Med Sci. 2009;24(5):715-20.
2. Carrara SV, Conti CR, Barbosa JS. Statement of the 1st Consensus on Temporomandibular Disorders and Orofacial Pain. Dental Press J Orthod. 2010;15(3):114-20.
3. Dworkin SF. Research diagnostic criteria for temporomandibular disorders: current status & future relevance. J Oral Rehabil. 2010;37(10):734-43.
4. Demirkol N, Sari F, Bulbul M, Demirkol M, Simsek I, Usumez A. Effectiveness of occlusal splints and low-level laser therapy on myofascial pain. Lasers Med Sci. 2014;7. [Epub ahead of print]
5. de Moraes Maia ML, Ribeiro MA, Maia LG, Stuginski-Barbosa J, Costa YM, Porporatti AL, et al. Evaluation of low-level laser therapy effectiveness on the pain and masticatory performance of patients with myofascial pain. Lasers Med Sci. 2014;29(1):29-35.
6. Curl DD. Discovery of a myofascial trigger point in the buccinator muscle: a case report. Cranio. 1989 Oct;7(4):339-45.
7. Giamberardino MA, Affaitati G, Fabrizio A, Costantini A. Myofascial pain syndromes and their evaluation. Best Pract Res Clin Rheumatol. 2011;25(2):185-98.
8. Cummings M, Baldry P. Regional myofascial pain: diagnosis and management. Best Pract Res Clin Rheumatol. 2007;21(2):367-87.
9. Aras MH, Güngörmüş M. The effect of low-level laser therapy on trismus and facial swelling following surgical extraction of a lower third molar. Photomed Laser Surg. 2009;27(1):21-4.
10. Nammour S. Laser dentistry, current advantages, and limits. Photomed Laser Surg. 2012;30(1):1-4.

11. Vernon H, Schneider M. Chiropractic management of myofascial trigger points and myofascial pain syndrome: a systematic review of the literature. J Manipulative Physiol Ther. 2009:32(1):14-24.
12. Annaswamy TM1, De Luigi AJ, O'Neill BJ, Keole N, Berbrayer D. Emerging concepts in the treatment of myofascial pain: a review of medications, modalities, and needle-based interventions. PM R. 2011 Oct;3(10):940-61.
13. Melchior Mde O, Venezian GC, Machado BC, Borges RF, Mazzetto MO. Does low intensity laser therapy reduce pain and change orofacial myofunctional conditions?. Cranio 2013;31(2):133-9.
14. Amanat D, Ebrahimi H, Lavaee F, Alipour A. The adjunct therapeutic effect of lasers with medication in the management of orofacial pain: double blind randomized controlled trial. Photomed Laser Surg. 2013;31(10):474-9.
15. Kingsley JD, Demchak T, Mathis R. Low-level laser therapy as a treatment for chronic pain. Front Physiol. 2014;19(5):306.
16. Núñez SC, Garcez AS, Suzuki SS, Ribeiro MS. Management of mouth opening in patients with temporomandibular disorders through low-level laser therapy and transcutaneous electrical neural stimulation. Photomed Laser Surg. 2006;24(1):45-9.
17. Chung H, Dai T, Sharma SK, Huang YY, Carroll JD, Hamblin MR. The nuts and bolts of low-level laser (light) therapy. Ann Biomed Eng. 2012;40(2):516-33.
18. Caprioglio C, Olivi G, Genovese MD. Lasers in dental traumatology and low level laser therapy (LLLT). Eur Arch Paediatr Dent. 2011;12(2):79-84.
19. Brignardello-Petersen R, Carrasco-Labra A, Araya I, Yanine N, Beyene J, Shah PS.Is adjuvant laser therapy effective for preventing pain, swelling, and trismus after surgical removal of impacted mandibular third molars? A systematic review and meta-analysis. J Oral Maxillofac Surg. 2012;70(8):1789-801.
20. Huang YY, Sharma SK, Carroll J, Hamblin MR. Biphasic dose response in low level light therapy – an update. Dose Response. 2011;9(4):602-18.
21. López-Ramírez M, Vílchez-Pérez MA, Gargallo-Albiol J, Arnabat-Domínguez J, Gay-Escoda C. Efficacy of low-level laser therapy in the management of pain, facial swelling, and postoperative trismus after a lower third molar extraction. A preliminary study. Lasers Med Sci. 2012;27(3):559-66.
22. Silva DF, Mesquita-Ferrari RA, Fernandes KP, Raele MP, Wetter NU, Deana AM. Effective transmission of light for media culture, plates and tubes. Photochem Photobiol. 2012;88(5):1211-6.
23. Rodrigues H. Técnicas anatômicas. 2ª Ed. Vitória ES: Artes Visuais, 1998.
24. Cury FS. Técnicas anatômicas no ensino da prática de anatomia animal. Pesq Rev Bras. 2013;33(5):688-96.
25. Silva EM. Estudo analítico da técnica de glicerinação empregada para conservação de peças anatômicas: experiência da disciplina de Anatomia Humana do Departamento de Morfologia da UniFOA. Cadernos UniFOA. 2008. p. 66-9.
26. Melis M, Di Giosia M, Zawawi KH. Low level laser therapy for the treatment of temporomandibular disorders: a systematic review of the literature. Cranio. 2012;30(4):304-12.
27. Salmos-Brito JA1, de Menezes RF, Teixeira CE, Gonzaga RK, Rodrigues BH, Braz R, et al. Evaluation of low-level laser therapy in patients with acute and chronic temporomandibular disorders. Lasers Med Sci. 2013;28(1):57-64.
28. Kogawa EM, Kato MT, Santos CN, Conti PC. Evaluation of the efficacy of low-level laser therapy (LLLT) and the microelectric neurostimulation (MENS) in the treatment of myogenic temporomandibular disorders: a randomized clinical trial. J Appl Oral Sci. 2005;13(3):280-5.
29. Venancio RA, Camparis CM, Lizarelli R de F. Low intensity laser therapy in the treatment of temporomandibular disorders: a double-blind study. J Oral Rehabil. 2005;32(11):800-7.
30. Venezian GC, da Silva MA, Mazzetto RG, Mazzetto MO. Low level laser effects on pain to palpation and electromyographic activity in TMD patients: a double-blind, randomized, placebo-controlled study. Cranio. 2010;28(2):84-91.
31. Enwemeka CS. Intricacies of dose in laser phototherapy for tissue repair and pain relief. Photomed Laser Surg. 2009;27(3):387-93.
32. Jacques SL. Optical properties of biological tissues: a review. Phys Med Biol. 2013;58(11):R37-61.