The State of the Art of Lasers in Esthetics and Prosthodontics

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The clinical cases have been published in the book Estética com as Porcelanas de Última Geração (Eduardo et al, 2004), and the publication of figures is authorized by Livraria Santos Editora Ltda.

Abstract: This article puts forward the state of the art of laser in esthetic and prosthetic dentistry from a clinical point of view, based on research that supports the indications described. A review of relevant studies provides an overview of possibilities and limitations of the use of lasers in esthetic and prosthetic dentistry. Numerous studies in the literature have reported the benefits of laser use, and based on the laboratory and clinical evidence, a protocol for use of lasers in esthetic and prosthetic dentistry is suggested. Understanding how high- and low-intensity lasers may be employed in soft- and hard-tissue management may help the professional in selecting the best protocol for a specific clinical application. This understanding is important to clinical success, where excellence in esthetics should parallel oral health maintenance.

Keywords: esthetics, lasers, prosthodontics.

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Specialists from various areas in dentistry are frequently resistant to introducing up-to-date technologies that may threaten the knowledge that they have acquired and consolidated through long years of experience and qualification in their areas of expertise.

The appearance of laser technology, referred to by Albert Einstein in 1917, put into practice by Maimann in 1960, and improved by physicists who have worked on the development of equipment in a constant endeavor to implement new resources and make them feasible for everyday clinical use, is perhaps a threat to all those who cannot bear changes. However, a new century has arrived and these changes are more noticeable by the day. Although many benefits of the use of lasers in dentistry have been reported, difficulties in knowledge dissemination, popularization, and greater recognition of laser use still exist.

WHY ARE MANY PROFESSIONALS AGAINST LASER TECHNOLOGY?

In disseminating and popularizing of the use of lasers in dentistry, two major disadvantages are always mentioned: in addition to professionals having to purchase high-intensity laser equipment, they would also have to invest in studying its proper application. Not knowing safe, optimal parameters and protocols can lead to improper use of laser equipment and thus harm to patients.

Fig 1 LELO library.

Fig 2 Aircraft.

The fundamental difference between other new technologies in dentistry and laser technology is the fact that for the majority of the former, a course lasting a few hours is sufficient to qualify the dental surgeon to use them, whereas with laser, a minimum curriculum with a large number of hours dedicated to this speciality should be established so that professionals understand absorption by the irradiated tissue (hard or soft) for the benefit of the patient.

Many professionals take up a position against laser technology, firstly because of the cost, and secondly because of lack of scientific knowledge and information on the use of lasers in dentistry. Laser technology is often compared to the technology of a "Boeing" jet airplane, for which its captains need a great deal of theoretical training, then many hours in flight simulators, and finally practice flights, with great importance attached to the number of flying hours. As the number of their flying hours increases, they become increasingly qualified, with the end purpose of achieving the safety of the aircraft and passengers.

When deciding to buy high-power laser equipment, the professional must also follow some prerequisites necessary for using it:

- Prior knowledge of laser technology
- Knowledge about the absorption of laser by the irradiated tissue, as well as its wavelength and different specialties in which it may be used
- Short-duration courses
- Workshops of longer duration for knowledge about the technology
- Search through current literature providing knowledge of the methodologies and materials used
- Study of parameters for the use of laser technology
- Those who wish to go more deeply into and specialize in laser in dentistry should take specific Master's and Doctoral courses (both of long duration) in order to enable them to broaden their knowledge for clinical use, attain excellence, contribute towards enhancing the patients' quality of life, and provide them with many benefits.

This being so, captains with many flying hours may be compared to dental professionals with many hours of study, knowledge, and use of laser technology.

It is also useful to compare an aircraft to the library, in which the speed of information may take one to greater knowledge, a vehicle and storehouse alike. (Figs 1 and 2).

LASERS IN ESTHETIC AND PROSTHETIC DENTISTRY

Only by a great deal of study of the fascinating field of lasers in dentistry are we able to understand its absorption by the target tissues and its various wavelengths, and transform this knowledge into safe use on patients.

The last decade was notable because of the great evolution in adhesive systems, compound resins, and porcelain for indirect restorations, which has had a significant effect on esthetics and dental prostheses. Pa-

Fig 3 Old porcelain laminate veneers in teeth 11 and 21.

Fig 4 New porcelain laminate veneers (11 and 21) and new applications of low level laser AsGaAl (4 sessions, 4 J/cm^2) to maintain esthetics.

tients and professionals increasingly appreciate the esthetic results. Many researchers support this evolution, and good esthetic clinical results have enhanced and highlighted the work of dental professionals.

The physical development of lasers and the understanding of the various wavelengths, as well as the improvement of equipment by investing millions of dollars in its modernization and manufacture, have brought these two areas closer together, with laser representing an upgrade of dentistry as a whole, particularly in esthetics and prosthetics.

Costs vs Benefits

The use of laser in daily clinical work is becoming a reality, helping to correct the view that laser procedures are too sophisticated and lead to higher costs without the corresponding benefits.

The intention of this article is to show that items of laser equipment can and should be incorporated into daily work in such a way that the same item of equipment may be used for many hours a day by many professionals working together in clinical practice, thereby improving its cost:benefit ratio and broadening the range of indications.

Indications for High- and Low-intensity Laser Therapy (HILT and LILT) (Figs 3 and 24)

1. HILT laser curettage in the gingival sulcus (prior to tooth preparation)
2. HILT laser curettage in the gingival sulcus (prior to impression procedures)
3. LILT tooth conditioning after the vitalized tooth preparation previously used
4. LILT of gingival tissue after the placement of the provisional restoration
5. LILT of gingival tissue (during the appointments before the final cementation or luting)
6. HILT for tooth decontamination prior to the final cementation – directly on the dentin of the tooth preparation
7. HILT laser curettage in the sulcus of the periodontal tissue every 3 to 6 months, if necessary for the maintenance of periodontal health
8. LILT gingival tissue conditioning at every follow-up appointment and to maintain the esthetics achieved between the porcelain and the gingival tissue

Fig 5 Initial oral situation.

Fig 6 Nd:YAG DEKA laser irradiation for gingival curettage (1.5 W, 15 Hz, 100 mJ).

Fig 7 View of occlusal situation during laser irraditaion.

Fig 8 Initial situation: oral view before treatment.

Fig 9 Final view of the maxillary incisors with porcelain laminate veneers.

PROTOCOL FOR LATEST GENERATION PORCELAINS

1. HILT laser curettage in the gingival sulcus prior to tooth preparation

Laser curettage in the gingival sulcus, for example, with Nd:YAG laser (1064 nm) has been approved by the Food and Drug Administration (FDA) in the United States since 1997. In this specific case, if one is thinking of dental esthetics, it is also necessary to think of periodontal esthetics (Figs 5 to 9). Therefore, the gingival tissue must be in very good condition before cavity preparations are started. Microbial reduction in these periodontal pockets has been shown by the work of Ben Hatit et al,[3] Moritz,[12] and Gutknecht[7,8] over the last ten years.

The use of Er:YAG laser on root cement has also been well validated in the work of Aoki, Sasaki, Watanabe, and Ishikawa[2,9] in Japan, Schwartz[16] in Germany, Feist et al[6] in Brazil, and in that of many other authors.

2. HILT laser curettage in the gingival sulcus prior to the impression procedure

Quite frequently there is highly inflamed gingival tissue before the impression procedure, and laser curettage has to be repeated with the intention of carrying out the impression procedure in the following week under ideal conditions, without inflammatory exudation or gingival bleeding around the cavity preparation (Figs 10 to 15).

Fig 10 Esthetic rehabilitation, pretreatment view.

Fig 11 Tooth preparation before HILT.

Fig 12 Nd:YAG laser gingival curettage (DEKA, 1.5 W, 15 Hz, 100 mJ).

Fig 13 Inicial situation.

Fig 14 Final prosthetic rehabilitation.

Fig 15 Final prosthetic rehabilitation.

Fig 16 Low-level laser irradiation after tooth (vitalized) preparation in young patient.

Fig 17 Final porcelain laminate veneer reconstruction from canine to canine. Note periodontal health.

3. LILT tooth conditioning after tooth preparation in vitalized teeth

Whenever cavity preparation is carried out, pulp irritation and inflammation can be caused by the aggression of cutting the odontoblastic prolongations that come from the pulp and extend to the dentin. In addition to the cut, there may also be an increase in temperature that is transmitted to the pulp and which, according to Zach and Cohen,[20] must not exceed 5.2°C, as it already causes pulp inflammation.

For this purpose, LILT with its anti-inflammatory and biostimulating action may be a very important adjuvant treatment for a better postoperative period after tooth preparation, with less pain from pulp trauma. LILT is used in the direction of the dentin tubules in contact with the tooth structure, scanning the entire cavity preparation, and requiring an average of 3 to 5 min per tooth prepared. Low-power AsGaAl lasers are used, and this procedure may be repeated whenever temporary acrylic crowns are removed during the process of doing the definitive work (porcelain crowns, for example).

High levels of PGE2 (prostaglandin E2) and IL1-beta (interleukin 1-beta) are found in the periodontal ligament during tooth movement, and both factors are involved in the induction of pain. Shimizu et al[17] showed that LILT can inhibit the increase of PGE2 and IL-α in vitro.

Frequently, high-power Nd:YAG (1064 nm), Er:YAG (2.94 µm), high-power diode (980 nm), and Er,Cr:YSGG (2.79 µm) lasers may be used in unfocused mode, working like low power lasers at very low power densities. The clinical response has been very satisfactory in these procedures (Figs 16 and 17).

4. LILT gingival tissue conditioning after temporary resin restoration

There is always cavity preparation trauma to the periodontal tissue and the gingiva shows inflammation. Some LILT sessions are done on the gingiva surrounding the cavity preparation in order to reduce or eliminate inflammation.

Karu et al[10,11] and many other authors[14,15] report on the use of low-power laser with its anti-inflammatory and biostimulating effect, but its use on inflamed gingiva has been studied by Silveira,[18] Sousa,[19] and Amorim[1].

A Ga-As diode laser (904 nm) at 3 J/cm^2 can stimulate fibroblast proliferation. This is important to enhance wound healing.[14]

5. LILT gingival tissue conditioning

Some sessions are necessary for obtaining the benefits of using laser related in item 4 (above) . The desired benefit cannot be obtained in one application of laser (LILT) to the gingival tissue. At least 5 to 6 sessions must be performed.

Care is taken to have healthy gingiva surrounding the tooth preparation in order to avoid postoperative retraction of the gingival tissue, with exposure of the cervical end of the preparation. This would completely compromise the good esthetics achieved with the latest generation of porcelains (Fig 18 to 20).

Fig 18 Low-level laser application in gum close to tooth preparation.

Fig 19 Low-level laser application in gum close to porcelain after cementation.

6. HILT tooth decontamination / preparation prior to definitive cementation of the porcelain crowns

When the protocol for the latest generation of porcelains is carried out, as will be referred to at the end of this article, it frequently takes 4 to 6 months to finish the work of reconstruction. During this time, the temporary resin crowns are luted with provisional cement. They may be submitted to temperature contractions and expansions, and therefore there may be leakage and contamination of the prepared cavities, with the presence of undesirable microorganisms inside the coronal dentin. To kill bacteria, Er:YAG laser is used as a last step,[4,13] with no loss of bond strength. The microbial reduction in dentin of the prepared cavity and the bond strength of the porcelain to the tooth structure are of utmost importance to achieve a successful and esthetic outcome.

In the near future, further research may prove that other lasers – such as Er,Cr:YSGG and Ho:YAG – may be effective for this indication (Fig 21 and 22).

7. HILT laser curettage in the gingival sulcus every 3 to 6 months after final cementation of the porcelain crowns and laminate veneers

The patient should be forewarned that the attainment and maintenance of good dental esthetics is not linked to the act of definitive cementation. He/she should be extremely motivated to maintain gingival health, which is of the utmost importance.

Fig 20 Final rehabilitation in anterior teeth.

All the methods (dental floss, single tuft brushes, normal brushes) must be explained to the patient with the purpose of alerting and motivating him/her to uphold the esthetic result achieved for many years to come. This is why follow-up is necessary every 3 to 6 months at most. High-power laser treatment (HILT) may be used whenever it is considered necessary to maintain good esthetics.

8. LILT gingival tissue conditioning at follow-up

Whenever the patient comes to the clinic or office for a follow-up examination, low-power laser should be applied to the gingiva surrounding the luted porcelain to maintain the dental esthetics achieved. GaAlAs diode laser significantly inhibited PGE2 production in vitro (see above). The findings suggest that low-level laser ir-

Fig 21 Er:YAG laser irradiation before luting (60 mJ, 10Hz, 50/10 fiber; Key Laser, Kavo).

Fig 22 Porcelain crown reconstruction.

Fig 23 Er:YAG laser irradiation (160 mJ, 4 Hz to groove; 80 mJ, 4 Hz to etch).

Fig 24 Canine guidance reconstruction.

radiation may be of therapeutic benefit against the aggravation of gingivitis and periodontitis by bacterial infection.[15]

The protocol for the latest generation of porcelains is to be found in the book by Eduardo et al,[5] in which high- and low-power lasers are integrated and are a mandatory bridge to them:

- clinical and radiographic exams
- initial pictures
- impression for the temporary restoration
- tooth preparation and placement of the temporary restoration
- final preparation and final finishing of the preparation
- lining of the temporary restoration
- laser curettage in the gingival sulcus
- impression with addition silicone
- first time at the laboratory – choice of color
- proof of the porcelain coping (use of latest generation of porcelains)
- proof of the porcelain structure
- second time at the laboratory – final mapping of color
- proof of the porcelain restoration
- final luting
- final pictures

CANINE GUIDANCE RECONSTRUCTION

Often, the patients lose canine guidance due to constant abrasion. Thus, it is necessary reconstruct guidance to restore proper occlusion and eliminate occlusal interferences (Figs 23 and 24).

CONCLUSIONS

Dental esthetics is only attained if periodontal health is preserved. It is difficult to maintain, and constant follow-ups are therefore required. All of the traditional dentistry procedures must be used and preserved, but the use of lasers should represent an upgrade of great importance in the constant effort to improve esthetics.

Adjuvant laser treatment – this is how the use of laser in dental esthetics should be seen. It is based on obtaining a microbial reduction either in the gingival sulcus or in the contaminated dentin. Whenever high-power lasers are used on the cavity preparation to reduce the number of microbes, the parameters must be strictly kept to avoid loss of bond strength to the tooth structure.

Exaggerated marketing and publicity must be recognized for what it is, and care must be taken not to undermine the seriousness and credibility of the use of lasers in dentistry. To this end, it is vital to have knowledge of the scientific research carried out on these procedures.

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REFERENCES

1. Amorim JCF. Gingival healing after gingivectomy procedure and low intensity laser irradiation. A clinical and biometrical study in anima nobile. 2001. Dissertation (Professional Master's Degree "Lasers in Dentistry") - Nuclear and Energy Research Institute / School of Dentistry, University of São Paulo, São Paulo.
2. Aoki A, Sasaki KM, Watanabe H, Ishikawa I. Lasers in nonsurgical periodontal therapy. Periodont 2000 2004;36:59-97.
3. Ben Hatit Y, Blum R, Severin C, Maquin M, Jabro MH. The effects of a pulsed Nd:YAG laser on subgingival bacterial flora and on cementum: an in vivo study. J Clin Laser Med Surg 1996;14:137-143.
4. Blay CC. Análise comparativa da redução bacteriana com irradiação do laser de Er:YAG ou ponta montada em alta rotação após remoção de tecido cariado em dentina: estudo in anima nobile. 2001. Dissertação Mestrado Profissionalizante - IPEN.
5. Eduardo CP et al. Estética com as porcelanas de última geração: uma questão de protocolo. São Paulo: Livraria Santos Editora, 2004.
6. Feist IS, De Micheli G, Carneiro SR, Eduardo CP, Miyagi S, Marques MM. Adhesion and growth of cultured human gingival fibroblasts on periodontally involved root surfaces treated by Er:YAG laser. J Periodontol 2003;74:1368-1375.
7. Gutknecht N, Eduardo CP. A Odontologia e o Laser: Atuação do laser na especialidade odontológica. São Paulo: Quintessence, 2004.
8. Gutknecht N, Franzen R, Schippers M, Lampert F. Bactericidal effect of a 980-nm diode laser in the root canal wall dentin of bovine teeth. J Clin Laser Med Surg 2004;22:9-13.
9. Ishikawa I, Sasaki KM, Aoki A, Watanabe H. Effects of Er:YAG laser on periodontal therapy. J Int Acad Periodontol 2003;5:23-28.
10. Karu TI, Pyatibrat LV, Kalendo GS. Photobiological modulation of cell attachment via cytochrome c oxidase. Photochem Photobiol Sci 2004;3:211-216.
11. Karu TI. Photobiological fundamentals of low-power laser therapy. J Quantum Eletronics 1987;10:1703-1717.
12. Moritz A, Gutknecht N, Schoop U, Goharkhay K, Doertbudak O, Sperr W. Irradiation of infected root canals with a diode laser in vivo: Results of microbiological examinations. Lasers Surg Med 1997;21:221-226.
13. Navarro RS, Carrieri TCD, Freitas PM, Eduardo CP, Mori M. Tensile strength of adhesive resin cement to Er:YAG laser pre-treated dentin [P32]. ESOLA -Laser Congress 2005 Barcelona, 2005, p.45.
14. Pereira AN, Eduardo CP, Matson E, Marques, MM. Effect of low power laser irradiation on cell growth and procollagen synthesis of cultured fibroblasts. Lasers Surg Med 2002;31:263-267.
15. Sakurai Y, Yamaguchi M, Abiko Y. Inhibitory effect of low level laser irradiation on LPS stimulated prostaglandin E2 production and cycloxygenase-2 in human gingival fibroblasts. Eur J Oral Sci 2000;108:29-34.
16. Schwarz F, Sculean A, Berakdar M, Georg T, Reich E, Becker J. Periodontal treatment with an Er:YAG laser or scaling and root planing. A 2-year follow-up split-mouth study. J Periodontol 2003;74:590-596.
17. Shimizu N, Yamaguchi H, Goseki T, Shibata Y, Takiguchi H, Iwasawa T, Abiko Y. Inhibition of prostaglandin E2 and interleukin 1, production by low-power laser irradiation in stretched human periodontal ligament cells. J Dent Res 1995;74:1382-1388.
18. Silveira LB, Silveira LB; Ribeiro MS; Garrocho AA; Novelli MD; Marigo HA; Groth EB et al. In vivo study on mast cells behaviour following low-intensity visible and near infrared laser radiation [abstract 304]. Laser Surg Med 2002;(abstract issue):82.
19. Sousa GR. Avaliação radiográfica da reparação óssea em lesões perirradiculares de elementos dentários submetidos à radiação com laser de baixa intensidade de λ = 904nm. (Estudo in anima nobile). 2001. Dissertação Mestrado Profissionalizante - IPEN.
20. Zach L, Cohen G. pulp response to externally applied heat. Oral Surg Oral Med Oral Pathol 1965;19:515-530.

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