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Laser dentistry—deeply rooted in science

Dr Georg Bach

Dear colleagues,

This year's annual DGL Congress in Leipzig, Germany, has born eloquent witness to how much laser-supported therapies have become rooted in evidence-based dentistry and the dental world of science. However, the congress is only one among many factors which have contributed to this appreciation of laser dentistry.

Not only is laser dentistry's becoming rooted deeply in the scientific field the outcome of this development, but it has also become both the task and the aim not to linger on this sometimes delightful and sometimes stony path, but to keep moving on.

This task also includes fields of laser dentistry which would not be in the focus of our interest in the first place, but which are of great importance nonetheless. In this regard, I would like to recommend to you the baseline report on the preparation of medical products by our colleagues from Bonn, Germany, which you can find on page twelve of this issue.

An exciting and fulfilling year of both applied laser dentistry and studies in laser dentistry is coming to its end. I would like to use this opportunity to thank all authors who have contributed their articles to laser international magazine of laser dentistry over the past year. I furthermore want to thank DGL (Germany Society for Laser Dentistry) for supporting this publication as well as the editors of OEMUS MEDIA AG. I sincerely hope that we will continue our harmonious and constructive collaboration next year!

Dear colleagues and readers of laser international magazine of laser dentistry, I wish you all a happy, healthy and successful new year!

Warm regards,

Georg Bach


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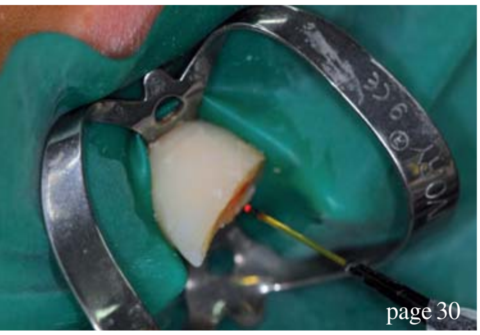
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Lasers in soft tissue dentistry

Author_Dr Vrinda Rattan, India

_Introduction

Lasers have revolutionised the medical management since the 1960s. Unlike many fields of medicine and surgery, where laser treatment represents a sole source of remedy, in dentistry the use of a laser is considered an adjunctive in delivering a stage of tissue management conducive to achieving a completed hard or soft tissue procedure. The adjunctive use of lasers in the field of periodontics has helped to achieve efficient cutting of dental hard tissue, haemostatic ablation of soft tissue, the disinfecting effect through bacterial elimination and an enhanced biochemical pathway associated with tissue healing.

Wonders of "Light Amplification by Stimulated Emission of Radiation"

LASERS are named according to the active elements that are involved in the creation of the energy beam. Thus, lasers commonly used in dentistry consist of a variety of wavelengths delivered as either a continuous, pulsed, or running pulse waveform, e.g., CO_2, Nd:YAG, Ho:YAG, Er:YAG, Er, Cr:YSGG, Nd:YAP, GaAs (diode), and argon.

Lasers emit energy which is essentially a light of one colour (i.e., monochromatic) and, therefore, of one wavelength. This wavelength defines its properties and its usage in various fields. The photons in its energy beam are emitted as a coherent (in phase), unidirectional, monochromatic light that can be collimated into an intensely focused beam that exhibits little divergence. On focusing the energy beam on the target site, the energy can become absorbed, reflected, or scattered. A photothermal phenomenon occurs when this light is further converted into heat energy. This energy can cause coagulation, incision, or tissue vaporization in a biological tissue, depending upon the wavelength of laser used, power, waveform, pulse duration, energy density, duration of exposure, angulation to the target surface, and optical properties of the tissue.

_History of lasers in dentistry

Maiman in 1960 used a crystal medium of ruby that emitted a coherent radiant light from the crystal when stimulated by energy for the extraction of teeth, based on Albert Einstein's theory of spontaneous and stimulated emission of radiation.[1,2] In 1961, Snitzer put forth his publication on the prototype for the Nd:YAG laser.[3] Goldman et al.[4] and Stern and Sognnaes[5] described the effects of the ruby laser on enamel and dentin.

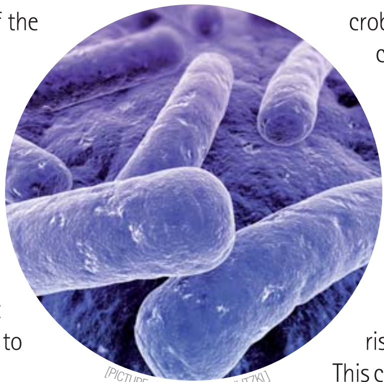
Commercial use of lasers and its marketing was pioneered by Dr Terry Myers.[6] This laser used an active medium of Nd:YAG, emitted pulsed light. In the early 1990s, laser machines which were used in the field of medicine were modified to be made available for dental use.

Different laser systems have gained more significance in the treatment of periodontal diseases. At the same time, it has become important for the surgeon to always be aware of the possibilities and limitations of lasers. The application of lasers is to be regarded as an adjunct to the conventional treatment methods for periodontal diseases.

The use of surgical lasers in periodontology is explored in three areas of treatment:

- Removal of the lining epithelium of the diseased pocket wall.
- Antimicrobial effect of lasers on pocket microbiota.
- Removal of calculus and root surface detoxification.

Benefits of laser use can be employed as an adjunctive, to maximise the outcome of the treatment, but lasers cannot be used as an alternative to conventional periodontal therapy.


[PICTURE: ©SEBASTIAN KAULITZKI]

_Laser and Pocket Debridement

Access into the periodontal pocket was made simple by the advent of the quartz optic fibre delivery system associated with the diode and Nd:YAG groups of lasers. The wavelength of these lasers ranged from 200 to 320 µm. Following the removal of calculus and plaque through scaling and/or root planing, the pocket depth is assessed. The laser fibre is adjusted to a length of one to two millimetres short of the pocket depth. It is made sure that the angle of insertion makes contact with the soft tissue wall at any time. In a light contact mode with sweeping stroke, the soft tissue lining of the pocket wall is ablated, beginning from the base of the pocket and proceeding upwards. Each pocket site should be ablated for a period of about 20–30 seconds, which would mean two minutes per tooth site, with re-treatment nearly at weekly intervals during a maximum period of four weeks. Multiple laser-based studies have been carried out. Case reports[7–10] have suggested that the diode laser (810 nm), along with the Nd:YAG laser (1,064 nm), has shown appreciable improvement in the periodontal status for the treatment of periodontal pockets by laser sub-gingival curettage. A study by Evans[11] reviewed the new attachment procedure on a sample of six cases which showed new cementum and bone growth, including periodontal ligament regeneration. Various controlled studies have assessed the use of laser therapy along with conventional scaling and root planing, although these investigations demonstrated no significant benefit in the treatment outcomes.[12,13]

_Antimicrobial effect of lasers on pocket microbiota

The complexity of the subgingival microbiota has been recognised by various microbiological techniques. The bacteria most commonly implicated in periodontal disease are *Actinobacillus actinomycetemcomitans, Porphyromonas gingivalis, Bacteroides forsythus, Treponema denticola* and *Prevotella intermedia*. Many studies have been carried out to demonstrate the antibacterial potential of laser energy on bacterial strains found in the diseased periodontal sites.[14,15] The theoretical basis of the use of laser as an antimicrobial is based on the absorption characteristics of the target bacterial structures like water content and pigments.

The build-up of the denatured protein material on the delivery fibre of the diode laser results in the development of a carbonised tip, which causes a rise in temperature beyond 700 °C. This char, if not removed, leads to a hot tip effect. The carbonised deposits cause secondary emission of radiant energy which leads to an unwanted damage. The bactericidal action can be enhanced by the use of a chemical mediator, such as methylene blue, which acts as a heat sink for the thermal energy. Antimicrobial photodynamic therapy can be readily applied, even in sites where there is limited access for mechanical instrumentation due to the anatomical complexity of the root. The antimicrobial effect of photodynamic therapy can be easily regulated by controlling the amount of light applied to activate the reaction.

_Removal of calculus and root surface detoxification

Laser-induced root surface modification is based on the selection of a wavelength that will effectively remove calculus and not allow any thermal damage to the pulp tissue and unwanted removal of sound root structure. This can be achieved only by the use of wavelength with minimal penetration depth in mineralised tissue. Lasers like CO_2, Nd:YAG, Er:YAG, and the diode have been used to study the surface detoxification of cementum and dentin.[16]

Hydroxyapatite forms the major mineral content of cementum and dentin which has absorption bands in the mid-infrared region. Of all the laser wavelengths studied, the Er:YAG laser proved to be the convincing laser of choice for effective removal of calculus, for root modification, and for surface modification for cell or tissue reattachment.

The CO_2 laser was the first of the wavelengths to be assessed for effects on root surfaces. Studies utilising CO_2 laser-treated surfaces have given conflicting results. Pant et al.[17] and Crespi et al.[18] found an increased *in vitro* attachment of fibroblasts to laser treated surfaces in comparison to controls of SRP or chemically treated surfaces. On the other hand, Fayad et al.[19] found a total lack of fibroblast attachment to irradiated surfaces. Heat-induced cracking of the root surface is a common observation when using the CO_2 laser.

Israel et al.[20] studied effects of CO_2, Nd:YAG, and Er:YAG lasers on root surface changes. At energy densities of 100 to 400 J/cm^2 for the CO_2 and 286 to 1,857 J/cm^2 for the Nd:YAG lasers, the authors found that the degree of morphologic change post laser irradiation was directly related to energy density, but unrelated to the use of an air/water surface coolant. Changes in root surfaces included cavitation defects, globules of melted and resolidified mineral, surface crazing, and production of a superficial char layer.

[PICTURE: ©NINELL]

Chen et al.[21], carried out a study in which cell cultures of human periodontal ligament fibroblasts were subjected to Nd:YAG irradiation at low energy densities. They reported significant decreases in cellular viability and collagen synthesis at five days post-treatment and evidence of mineralisation of necrotic cells at 28 days post-treatment. Laser parameters were 50 mJ of power and 10 Hz, with a defocused beam delivered through a 400-mm-diameter optical fiber, and durations of exposure ranging from 60 to 240 seconds. In contrast to studies reporting negative results, two *in vitro* studies have demonstrated that the Nd:YAG laser, when used at low energy densities or a combination of low energy density with a defocused beam, has the potential to remove root surface smear layers without causing collateral damage to underlying cementum and/or dentin, or causing irreversible pulpal damage or heat cracking.

The first study[22] used GaAs and GaAlAs diode lasers at energy densities between 0.95 and 6.32 J/cm^2, reported the effect of laser irradiation on prostaglandin E2 (PGE2) production and cyclooxygenase-1 (COX-1) and COX-2 gene expression in lipopolysaccharide challenged human gingival fibroblasts. The authors conveyed that irradiation with the GaAlAs diode laser significantly inhibited PGE2 production in a dose dependent manner, which lead to significant reduction of COX-2 mRNA levels. In another study[23], cell cultures of human gingival fibroblasts were irradiated with an Er:YAG laser at energy densities ranging from 1.68 to 3.37 J/cm^2 and actually increased the production of PGE2 and COX-2 mRNA.

_Conclusion

The use of lasers in periodontal treatment becomes even more complex because the periodontium consists of both hard and soft tissues. When lasers are applied to the root surface and alveolar bone, carbonisation and major thermal damage have been reported on target as well as adjacent tissues. Therefore, the use of lasers is limited to soft tissue procedures like gingivectomy, frenectomy, removal of granulation tissue during flap surgery, removal of melanin pigmentation and metal tattoos of the gingiva. The uses of lasers have also been investigated for subgingival debridement and curettage, osseous recontouring, as well as in implant surgery, maintenance of implants, and management of periimplantitis.

_Lasers—a boon or a bane?

A boon

Dental lasers are an asset in soft tissue surgeries because of their proven haemostatic effect. Lasers can be used either alone or in conjunction with conventional surgeries for the treatment of periodontitis. Their high antibacterial efficiency has also been shown to be useful for the resolution of periodontal pockets.

- Less operative time, minimum postoperative pain due to protein coagulum that acts as a biological dressing and seals the ends of sensory nerves.
- Relatively bloodless surgeries, ability to coagulate, vaporise and cut.
- Less mechanical trauma, minimal swelling and scarring.
- Sterilisation of the wound site.
- No incision, sutureless.
- Recommended for patients with systemic conditions like diabetes, heart diseases or for patients taking blood thinners.

A bane

Lasers have been claimed to be more efficient than conventional therapy. But there is limited evidence regarding lasers playing a role in root surface debridement, pocket sterilisation and elimination. Tissue charring or obnoxious fumes often prevent patient acceptance. Although lasers are the painless alternative to surgical treatment, they are still regarded as an adjunct to conventional treatment methods.

_Conclusion

Given the same wavelength, different laser parameters will yield different levels of energy density for varying periods of time and, thereby, different biological effects on the target tissue._

_contact laser

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