IS THERE A PLACE FOR LASERS IN PERIODONTAL THERAPY?

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ABSTRACT
This article aims to provide an overview on the clinical applications of lasers in periodontics.

Introduction
Lasers have been used in the field of dentistry for over 30 years. However, there has been a recent increase in patient awareness of the use of lasers and dentists have a duty to respond to patients’ enquiries or perceptions about laser technology.

Based on Albert Einstein’s theory of spontaneous and stimulated emission of radiation, Maiman from Hughes Research Laboratories developed the first laser prototype in 1960.1 His device used a ruby crystal that emitted a coherent radiant light when stimulated by energy. The application of the laser in dentistry today takes its origins from Myers and Myers in 1985, who described the in vivo removal of dental caries using a modified ophthalmic Nd:YAG laser.2 Four years later, the use of the Nd:YAG laser for oral soft tissue surgery was suggested; this has led to consideration of the use of lasers in clinical periodontics.

Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. The laser is a light source that produces a beam of monochromatic, focused, collimated and coherent light. Lasers are named according to the active element within them that goes through the stimulated quantum transitions that create the light. The wavelength of the light that a laser produces is characteristic of the particular active element and is the primary determinant of the degree to which the light is absorbed in the target material. The deeper the laser penetrates, the more it is scattered throughout the tissue. The depth of penetration is a critical feature that can influence its use for any particular application. Laser energy can be delivered by using either a continuous or pulsed waveform. Once the laser light is absorbed, it is converted to heat. The resultant effects are dependent upon the tissue composition and the exposure duration. Thermal increase may cause the tissue to alter in structure and composition. Changes may vary from warming (37-60°C), welding (60-65°C), coagulation (65-90°C), protein denaturation (90-100°C), drying (100°C), or vaporisation and carbonisation (over 100°C).3

Clinical applications in periodontics
Bacterial reduction and photodynamic disinfection
Gingival inflammation is promoted by bacterial colonisation especially by gram-negative rods, which are closely related to the destruction of the supporting tissues. Conventional methods, such as oral hygiene and debridement have not been effective in eliminating all types of bacteria involved in the pathogenesis of periodontal disease.4 The key bacteria frequently present within deep pockets include Aggregatibacter actinomycetemcomitans, Porphyromonas gingivalis, Bacteroides forsythus and Prevotella intermedia. Most reported studies focus on the action of various laser wavelengths on these selected bacterial species.5

The effectiveness of any laser wavelength is largely influenced by the absorption characteristics of the bacterial structure being matched by the incident beam. A number of studies demonstrate the effectiveness of laser energy on bacterial strains found in the diseased pocket and the findings are encouraging.6,7 However, the indeterminate existence of specific parameters of laser energy dosage, concentration of bacterial colonies and precision of exposure may give rise to some scepticism as to the predictability of this therapy.

A review paper by the American Academy of Periodontology states that current evidence suggests that use of the Nd:YAG or Er:YAG wavelengths for the treatment of chronic periodontitis may be equivalent to scaling with respect to a reduction in subgingival bacterial populations.8

Photodynamic therapy (PDT) utilises an oxygen-dependent photochemical reaction that occurs on light-mediated activation of a photosensitising compound leading to the generation of cytotoxic reactive oxygen species.9 Clinical studies claim that the adjunctive use of PDT along with scaling may result in greater bacterial reduction, clinical attachment level gains as well as a reduction in bleeding on probing and probing pocket depths, but there are insufficient studies to support this.10

Calculus removal
Calculus may act as a plaque retentive factor.11 Development of the Er:YAG laser and ErCr:YSGG laser (Figure 1) together with innovative near-UV wavelengths such as frequency-doubled alexandrite (FDA),...
has encouraged the safe use of lasers in calculus removal. Previously the use of Nd:YAG and CO2 lasers for this purpose suggested that calculus removal was incomplete and could potentially damage the surrounding tissues.\(^{15,17}\)

To provide adequate access to calculus deposits, specially designed laser handpiece tips have been developed (Figures 2a and 2b). The shorter FDA wavelength can be delivered through an optic fibre. The latter remains a developmental machine and requires further investigation. The advantage of using wavelengths close to 400 nm is based on studies that have shown the differential increased absorption of this laser by calculus, as opposed to cementum and dentine.\(^{18}\)

Due to their composition, both supragingival and subgingival calculus are vulnerable to de-fragmentation through photo-mechanical ablation with the erbium group of lasers.\(^{19,20}\) Potentially, this allows deposits to be removed using laser energy levels less than that required for the ablation of dental hard tissue. However, the efficiency of Er:YAG in calculus removal may be less than that of ultrasonic instrumentation.\(^{21}\)

**Laser-assisted new attachment procedure (LANAP)**

LANAP is a surgical therapy designed for the treatment of periodontitis through regeneration rather than resection. This technique uses pocket de-epithelisation as its basis. In LANAP surgery, a variable free-running pulsed Nd:YAG laser selectively removes diseased pocket epithelium from the underlying connective tissue. Since the laser energy is quite selective, the pleuripotential cells of the underlying connective tissue are spared, thus permitting healing and regeneration. This procedure does not however have a strong evidence-base.\(^{22}\)

All of the clinical applications discussed here aim to help achieve periodontal health. Reported cases of the use of lasers as an adjunct to conventional treatment show encouraging results (Figures 3a–d).

**Effect on hard tissues**

Several studies have evaluated the effects on hard tissues and bone when subjected to laser irradiation.\(^{23-25}\) Studies have confirmed the negative effects of the Nd:YAG and CO2 lasers when used directly on bone or root surfaces. These include thermal damage to underlying tissues.

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4 Microbiological tests for Actinobacillus actinomycetemcomitans and Porphyromonas gingivalis.
13 Albandar JM, Kingman A, Brown U, Loe H. Gingival inflammation and subgingival calculus as...
bone when used on thin soft tissue to perform gingivectomies. Additionally, a residual char formation that is produced during laser ablation of the hard tissues has been shown to inhibit attachment of fibroblasts and delay wound healing. The Er:YAG laser appears to leave the least thermal damage and creates a surface that suggests biocompatibility for soft tissue attachment. The effects on the root surface from this laser show an absence of melting, charring and carbonisation as seen with the Nd:YAG or CO2 lasers. As well as the type of laser used, potential laser-induced damage depends on the direction of the laser beam; there is no damage to root surfaces when the laser beam is directed parallel rather than perpendicular to the root surface.

The ErCr:YSGG laser has gained recent popularity and some claim that it can be used for laser cutting, shaving, contouring and resection of oral osseous tissues. However, there are no published studies on its use in surgical procedures, nor is there evidence to suggest this technique is superior to conventional osseous surgical methods.

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Effect on soft tissues

Traditional use of dental lasers for soft tissue ablation includes gingivectomy, frenectomy21 (Figure 4), removal of mucocutaneous lesions as well as gingival sculpting techniques associated with implant therapy and mucogingival surgery. In addition, several studies have found the laser removal of drug-induced gingival overgrowth to be an advantage over other surgical techniques.25-26

Biostimulation is the modification of the environment to stimulate existing health-associated bacteria. Conlan et al suggested that low-powered laser irradiation might affect biostimulation by interfering with cellular activities. However, the exact mechanism of biostimulation is still not fully understood and this requires further investigation. In addition, laser irradiation may interfere with cellular metabolic activities and affect the fibroblast attachment and production of procollagen and collagen.23

Ideally, laser effects on soft tissues should be minimal with atraumatic incisions, homogenous removal of tissue, coagulation of the wound surface yielding a dry surgical field and better visualisation, a positive effect on the healing process, minimal post-operative discomfort and high patient acceptance. Romanos and Nentwig suggested that laser treatment results in minimal or no post-operative swelling, bleeding, scar tissue formation or pain (lasers have a welding effect on nerve fibres).23

Dentine hypersensitivity

Dentine hypersensitivity is common in periodontal patients both pre- and post-treatment. Various techniques are currently used to treat sensitivity with different degrees of success; some aim to seal exposed dentinal tubules whilst others affect nerve activity. Ideally, treatment of this condition should be painless and affordable for the patient, easy to perform, non-irritant to the pulp, rapidly acting and effective for long periods of time.27-28 Existing treatment fails to satisfy all the requirements as repeated applications are usually necessary and beneficial effects appear to be short-term.

Lasers could provide a reliable and reproducible treatment for dentine hypersensitivity with success rates ranging up to 90%.29 Low output lasers such as the gallium-aluminum-arsenide laser and middle output lasers, which includes the Nd:YAG and CO2 laser have been suggested. The exact mechanism causing reduction in dentine hypersensitivity is mostly unknown, but it has been proposed that a specific mechanism exists in accordance with the laser type used. Lower powered lasers, such as the helium-neon laser, are thought to interfere...
with either the electrical activity or block the depolarisation of peripheral C-fibre afferents, inhibiting the initiation of the sensory nerve impulse. The use of the CO₂ laser at moderate energies causes sealing and occlusion of the dentinal tubules by coagulating the proteins in dentinal tubule fluid. The sealing depth, after CO₂ laser irradiation with either the electrical activity or the methods used; findings rely upon patient subjective opinion, as it is difficult to measure pain objectively.

Nonetheless, both the assessment and the evaluation of the treatment outcomes is difficult, regardless of the materials or the methods used. There may be a place for lasers in periodontics but the evidence base is still unclear. Due to the large number of variables involved, including the type of laser, wavelength, settings, angles and tips, results from existing studies are difficult to compare. The American Academy of Periodontology position is that there is currently insufficient evidence to suggest that the use of lasers is superior to conventional periodontal therapies. This lack of strong evidence is limiting widespread laser use and further well designed studies are required.

### Conclusion

There may be a place for lasers in periodontics but the evidence base is still unclear. Due to the large number of variables involved, including the type of laser, wavelength, settings, angles and tips, results from existing studies are difficult to compare. The American Academy of Periodontology position is that there is currently insufficient evidence to suggest that the use of lasers is superior to conventional periodontal therapies. This lack of strong evidence is limiting widespread laser use and further well designed studies are required.

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**Figure 5:** Wavelength specific safety glasses

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**References**


