LASER TECHNOLOGY TO MANAGE PERIODONTAL DISEASE: A VALID CONCEPT?

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ABSTRACT

Present day dental lasers can create oral environments conducive for periodontal repair.

Background and Purpose

With the bacterial etiology of periodontitis and the resulting host inflammatory reaction, clinicians continue to search for therapeutic modalities to assist in the nonsurgical management of periodontal disease. Traditional chairside therapies consist of mechanical debridement with manual and/or ultrasonic instrumentation with the objective of removing calculus, biofilm, and endotoxin from tooth root surfaces. Decreasing the microbial stimuli and associated end products decreases the inflammatory reaction and allows the host an opportunity to regenerate tissue through wound healing. The purpose of this article is to examine whether dental lasers, which have been in use for the past 3 decades, may augment traditional nonsurgical periodontal therapy.

Methods

Review of research publications related to lasers and non-surgical periodontics with attention focused on systematic studies.

Conclusions

Studies utilizing laser technology may demonstrate positive effects on 1) selectively decreasing the biofilm environment, 2) removing calculus deposits and neutralizing endotoxin, 3) removing sulcular epithelium to assist in reattachment and decreased pocket depth, and 4) biostimulation for enhanced wound healing. Comparisons of studies to determine the difference between lasers and their respective effects on the periodontium are difficult to assess due to a wide variation of laser protocols.

Key words: periodontitis, periodontal disease, laser, bio-stimulation, non-surgical periodontal debridement, diode laser, dental hygiene

INTRODUCTION

The primary objective of periodontal therapy is to maintain the dentition in comfort, function and esthetics. The focus of this management is centered on controlling both bacterial etiology and the host defense system through host modulation. Therapy is generally divided into two categories: 1) surgical and 2) nonsurgical periodontal therapy. The objective of nonsurgical therapy includes plaque biofilm control, supra- and subgingival scaling, root planing, and the adjunctive use of chemical agents. Scaling is defined as instrumentation of the crown and root surfaces of the teeth to remove plaque, calculus, and stains from these surfaces. Root planing is a treatment procedure designed to remove cementum or surface dentin that is rough, impregnated with calculus, or contaminated with toxins or...
microorganisms. An additional procedure called curettage has been also included in nonsurgical periodontal therapy and it includes the process of debriding the soft tissue wall of a periodontal pocket.

The objective of this paper is to introduce the role of lasers in accomplishing the objectives of nonsurgical periodontal management as related to both the stated goals of procedures within the management process and to investigate additional modalities such as biostimulation.

LASER FUNDAMENTALS
Laser was introduced into dentistry in the 1980’s, with significant attention for the past three decades (see Figure 1). Dental lasers are divided into several categories dependent on wavelength with most for dental use being in the range of 500 nm to 10,000 nm. Several media exist to generate the energy from semi conductors to crystals and each creates a particular wavelength with a particular affinity for a respective target (chromophore) based on absorption coefficients and depth of penetration (see Figure 2). A chromophore is the part of a molecule responsible for its color and attracts a particular wavelength. The chromophores found in the oral tissue are melanin, hemoglobin, oxyhemoglobin and water.

For the oral cavity, the target tissue for lasers is soft tissue is gingival epithelium and/or hard tissue containing apatite crystals in teeth and osseous structures. The interaction of the different wavelengths on targets can be photo thermal, photochemical, photomechanical and photo acoustic effects (see Figure 3). Since some laser media such as the diode are attracted to pigment they may be used for hemostasis and as an antimicrobial effect.1

MICROBIOLOGIC EFFECTS
A laser with its ability for irradiation will have an antimicrobial effect and thus the potential as an addition to traditional periodontal nonsurgical therapy.2 All lasers have some photo thermal effect and most periodontal pathogens are eliminated above 50 °C.1 Nd:YAG and diode lasers are absorbed by bacteria, especially those with pigmentation, and therefore reduce re-colonization.1 Predominate periodontal pathogens are gram negative anaerobic bacteria and include those that are considered to be black pigmented. The reduction in bacterial activity has a significant effect by decreasing the primary etiology of periodontal pathology, and can also impact wound healing with possible alleviation of patient discomfort.1 Nd:YAG lasers have a bactericidal effects against gram negative anaerobes including black pigmented Bacteroides and it has been shown that the Nd:YAG can selectively kill pigmented pathogens without disturbing surrounding tissues.1 Considerations for laser impact on black pigmented organisms are that these organisms are only pigmented when placed on blood cultures, while several other periodontal pathogens are not pigmented. Since diode lasers have an affinity for pigment they therefore can have a significant bactericidal effect when used in the sulcus (see Figure 4). This effect has also been seen when the diode was used with scaling and root planing with aggressive periodontitis when P. gingivalis and T. denticola were reduced more in the SRP with diode laser treatment than SRP or laser treatment alone.6 The erbium lasers also demonstrate some antimicrobial activity in endodontic procedures; this effect is not due to an attraction to bacterial pigment but more likely from a photo acoustic activity.7 Studies have compared periodontal treatment with Er:YAG versus scaling and root planing. The Er:YAG treatment resulted in greater gains in clinical attachment levels with the most significant difference in increased pocket depths. No differences were detected in the microbiological analysis of the study.8 Photodynamic therapy (PDT) may have potential as an adjunct to periodontal debridement. Whether using a ‘cold’
(low level) laser or a conventional dental laser as a diode or Nd:YAG, methylene blue dye can be placed in the sulcus as a subgingival irrigant. The laser wavelengths are attracted to the dye and interact with the medicament resulting in the disruption of the bacterial cell walls.9 The light energy activates the dye, interacts with intracellular oxygen, and destroys the bacterial organisms by lipid per-oxidation and membrane damage.9 A systematic review and meta analysis of the effect of photodynamic therapy for periodontitis demonstrated that PDT did not provide an additional positive effect in the management of periodontitis over routine scaling and root planing and thus could not be recommended as an adjunct to therapy.10

**ROOT SURFACE**

The Nd:YAG and diode lasers have a limited use in actual hard tissue root therapy for root detoxification or calculus removal since their targets are primarily soft tissue. The Nd:YAG laser produces pitting, charring, craters, and melting, even when applied parallel to the surface in in-vitro studies.11 Research demonstrates that the Nd:YAG laser could be effective at removing the smear layer without microstructural damages to the hard tissue, but it caused a significant rise in temperature that may cause it to be inappropriate for in vivo use11 (Figure 5).

Erbium lasers demonstrate possibilities for root debridement by their effect on calculus and necrotic cementum with reduction of endotoxins.12 Erbium lasers with water irrigation can remove calculus with little increase in temperature on the associated root surface. These studies have been conducted in both in-vitro and in-vivo environments.13 Erbium wavelengths also have been reported to remove endotoxin in in-vivo studies.14 Erbium lasers are as effective in removing calculus as manual/power instrumentation and demonstrate no thermal damage13 (see Figure 6). Limited in-vitro studies demonstrated that, gingival periodontal ligament fibroblasts adhere to lasered root surfaces in both attachment, spreading, and orientation comparably to surfaces treated with manual Gracey instrumentation.8

**SOFT TISSUE**

Most dental lasers have wavelengths that can remove the epithelium lining the sulcus.6 This may result from the photo thermal and/or the photo acoustic effect. Coagulation of the inflamed soft-tissue wall of a periodontal pocket and hemostasis are both achieved at a temperature of 60 °C.1 One of the most beneficial treatments in laser therapy is sulcular debridement.2 This process can be a complimentary adjunct to conventional root planing and scaling. The soft tissue laser cuts or ‘vaporizes’ soft tissue, referred to as ablation. Lasers can coagulate the tissue; controlled coagulation increases hemostasis and provides physical access.1

The benefit of laser use for soft tissue laser treatments and management is that the treatments are many times less invasive than allowing diseased tissue to be treated while
maintaining healthy tissue. There is evidence of increased attachment level gain over scaling and root planning due to these effects15 (see Figure 7a–d). The literature is replete with evidence that soft tissue curettage does not contribute to additional gains in attachment levels versus meticulous periodontal root planning in chronic adult periodontitis.16 Therefore, soft tissue lasers as the Nd:YAG and the diode laser may have limited application in the reattachment process for non-surgical periodontal therapy over scaling and root planing.

BIOSTIMULATION

The category of lasers referred to as low level light lasers (LLLT) are recognized for biostimulation and photo-bio modulation (PBM). These lasers use laser light energy, rather than heat therapy, to affect biological responses from the cells and cell responses. The laser and LED sources used for LLLT are between 600 and 950 nm (nm). The PBM affects the mitochondria of the cell, primarily cytochrome-c oxidase in the electron chain and porphyrins on the cell membrane, and increases mitochondria increasing adenosine triphosphate via oxidative phosphorylation and modulation of reactive oxygen. The resulting rise in energy decreases inflammation and enhances wound healing.17

Studies of biostimulation and periodontal therapy demonstrate changes in both clinical parameters and patient comfort.18 Studies utilizing photodynamic and LLLT in nonsurgical periodontal therapy demonstrated a decrease in inflammatory parameters including interleukin-1 B over controls of traditional debridement.19 Incorporating LLLT into non-surgical periodontal therapy has shown significantly more improvement in sulcus bleeding index (SBI), clinical attachment level, and probing depth (PD) levels compared to the control group, but no differences in decrease of growth factor-β1 levels.20

LASER EFFECT ON NON-SURGICAL CLINICAL PARAMETERS

Systematic reviews demonstrate minimal differences in non-surgical periodontal endpoints between laser therapy and conventional periodontal therapy. These systematic reviews involved various wavelengths including the Nd:YAG, diode, and erbium lasers. Treatments included both mono-therapy and adjunctive methods and reported no benefit over conventional therapy of ultrasonics and manual instrumentation using clinical parameters of plaque biofilm, and gains in clinical attachment levels efficacy except for the erbium laser.6 This may be due to the erbium wavelength having an affinity for root surfaces and calculus where other lower wavelengths have a detrimental effect on these surfaces.

CONCLUSION

Laser technology is a recent addition to the tools utilized in managing periodontal disease. It appears that the various wavelengths are effective as an antibacterial modality but possibly not from a photodynamic effect. In removing calculus and endotoxin from root surfaces, the erbium laser may be effective due to its affinity for hydroxyl apatite. Most laser wavelengths will remove sulcular epithelium and de-granulate wound areas. However, systematic reviews of non-surgical periodontal protocols do not suggest the use of lasers in decreasing pocket depth and increasing attachment levels with exception of possibly the erbium laser due to the affinity for root surfaces. A valid comparison with clinical studies involving the laser versus conventional therapy is challenging due to: 1) different laser wavelengths, 2) wide variations in laser parameters, 3) differences in well controlled experimental protocols with valid/reliable metrics and 4) inconsistencies in severity of the diagnosis and respective treatment protocols.1

Figure 6. Erbium lasers can have positive effects on both soft tissue (sulcular epithelium) and hard tissue (root surface and calculus).
REFERENCES

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