



The elimination of bacteria and biofilms in periodontal disease via the thermal laser

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Abstract

The breakdown of oral health is in almost all cases due to microbial infiltration; even in cases of neuromuscular failure due to faulty occlusion, microorganisms will take advantage of the body's stress and fatigue. Bacteria rarely travel alone or in free-floating plankton-like forms; instead they aggregate in colonies, in what are called microbial biofilms. These biofilms are nearly impossible to decimate with conventional methods alone, especially those of scaling, root planning, endodontic reaming, anti-microbial solutions and drug therapy. The purpose of this paper is to demonstrate the laser's innate capacity to destroy microorganisms and the biofilms that house and protect them in periodontal disease.

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1. Introduction

Laser is a modality of light and heat that has innate anti-microbial characteristics. **Laser's tightly bound and extremely coherent energy has a deep penetrating effect on tissue, bacteria and biofilms.**

The biofilm is a symbiotic aggregate of tens of millions to billions of mixed microorganisms. **Periodontitis is a disease of the biofilm.** The initiation and propagation of gum disease are dependent upon the presence of persistent bacterial plaque.

2. Biofilm

The histopathology of the oral lesion and its stages are consistent with the following pathology mechanisms. Bacterial plaque contains or produces substances capable of causing inflammation. Such substances can have direct effects on vasculature and on

leukocytes, inducing vasodilatation, increased gingival crevicular fluid and migration of neutrophils to the site. Substances in bacterial plaque may also interact with host systems involved in inflammation. In more advanced stages of the disease, it is likely that host cells such as monocytes, lymphocytes and fibroblasts “react” and thereby induce pathological changes that are consistent with a chronic inflammatory response [1].

The biofilm is a thick polysaccharide matrix that exhibits a lower metabolic rate; if it is not totally destroyed it will initiate the re-growth of the bacterial colony [2]. Bacteria need to be destroyed logarithmically because if not, their reproductive rates, which can be as short as half an hour, will easily reestablish a colony.

3. Photo/thermal laser

Laser is a photo/thermal device that is monochromatic, coherent and collimated. The laser is a physical determinant; lacking a specific lock and key chemical target, it acts directly on cellular structures, destroying cell walls, altering DNA, altering metabolic processes and ungluing the polysaccharide structure of the biofilm [3].

Lasers propel light, heat and electromagnetic energy directly into bacterial cells, which cannot defend against the extreme photodynamics of light, the dramatic rise in local tissue temperature and electromagnetic poisoning. The multiple modality dynamics allows for synergetic destruction of bacteria. Since the laser can be used selectively to remove necrotic tissue as well as the bacterial plaque without eliminating essential tissue, a conservative approach to surgery is viable and a benefit to the client.

4. Pathogenic plaque

The etiology of periodontitis is bacterial infection [4], resulting in a host inflammatory response; followed by an attempt at bio-modulation and tissue repair, involving leukocytes and helper cells to restore homeostasis. This attempt at homeostasis causes an uncontrolled release of pro-inflammatory mediators that release anabolic and catabolic processes causing tissue destruction in the host. Invariably, oxygen tension is low and ischemic and necrotic events occur, which benefit the bacterial colony.

If antibiotics or an anti-microbial solution is released in an effort to control or eliminate the infection, the swiftness of reproduction and genetic adaptability of the bacteria allow for the development of drug and chemical resistance.

Labyrinth-like, only the penetration of the exterior layers of plaque is possible; therefore a log kill is impossible. The bio-adaptive quality can be seen as bacteria shift from aerobic to anaerobic. The biogenesis of bacteria is impossible to determine; however, once there is an explosive proliferation of one or few microbes in the body, bio-balance is eliminated and pathogenicity begins.

As it ages its composition alters, the initial colonizers proliferate, altering the environment, and thereby enabling new and different bacterial species to inhabit and develop. This complex aggregation allows a number of interactions between microbial species producing substances that are used by others as nutrients [5].

5. Chronic inflammatory response

Once the biofilm is entrenched the inflammatory response may shift from acute to chronic. The normally catatoxic response becomes a syntoxic one, where the body encapsulates the biofilm separating it further from essential tissue and systems. The biofilm, isolated and encapsulated by necrotic ischemic tissue, inhibits anti-microbial solutions from penetrating. Furthermore, biodiversity of the plaque presents possibilities of mutation and genetic adaptability. Chronic inflammation thus becomes part of the disease process and must be eliminated.

6. Destruction of the pathogenic biofilm and the role of acute inflammation in healing

From a mechanical point of view (laser), tissue absorption becomes absolutely important in the removal of the hyper-inflamed state and the destruction of biofilms. It is partially the hyper-inflammatory state that allows for colonization, as it is a redundant immune response. It is only by returning to an acute inflammatory state, while removing the offensive biofilm, that gingival healing is possible. This is essentially what the laser is capable of creating, as the absorption rate in both the tissue and biofilm leads to the destruction of the biofilm and an acute inflammatory reaction in the body's tissue.

Tissue absorption of light creates thermal resonance, causing protein denaturation, tissue shrinkage, vaporization, tissue disintegration, cutting, ablation, etc. Ultrasonic scaling, in combination with the thermal resonance of laser, physically removes the offensive bacterial colony. Laser also eliminates cross-contamination of periodontal pockets. Thermal resonance will also create an acute inflammatory reaction in the affected tissue, stopping the insidiousness of the hyper-inflamed state by rerouting the immune response.

7. The biofilm as a polysaccharide matrix

The biofilm is a self-regulating community; as it ages, it shifts from a mostly aerobic to an anaerobic organization and from gram-positive to gram-negative species. Possibly utilizing dental calculus for adhesion because of its rough nature, the biogenic material is inter-dispersed throughout, allowing bacterial multiple strata.

Adhesion is important for microbial survival—otherwise, saliva, gingival crevicular fluid, blood and the mechanical forces in the mouth would dislodge the bacteria [6]. The unique glycocalyx matrix, which is an ordered array of fine fibers providing a thick, continuous, hydrated, polyanionic environment around the cells, possibly hinders the access that antimicrobial compounds have to the cell surface [7]. In addition to protecting bacteria from host defense and antibodies, the metabolic state of the biofilm also increases the resistance to antibiotics [2,8].

The polysaccharide matrix contains water channels and minute openings that allow for nutrients and other life-supporting elements to reach the bacterial colony [8]. The minute openings inhibit the entrance of larger cells and molecules used by the body in the

destruction of infection, including reactive oxygen species, and the slower metabolic rate prevents the effectiveness of antimicrobials and antibiotics [2,8]. According to one source, biofilm bacteria are 500 times more resistant to antibacterial agents than planktonic cells [9].

8. Discussion

Gram-negative bacterial species seem to proliferate in periodontal pockets; a further problem with the use of antimicrobials is the systemic release of endotoxins due to the log kill of gram-negative bacteria. Massive release of endotoxins may result in septic shock, fever and other complications due to the destruction of the cell wall, which liberates the endotoxins. **The thermal quality of the Nd:YAG laser seems to eradicate the cell wall entirely and prevent the release of endotoxins systemically** [3]. Combined modalities, such as the mechanical removal of plaque in conjunction with laser, as in the Laser ENAP or LANAP technique [10,11], maximize the tools that dentists can now utilize in the elimination of periodontal disease. An immune response is seen in Laser ENAP as there is an ancillary effect by ligament and bone regeneration in successful cases [10,11]. Further study and research into the destruction of biofilms via the use of laser needs to be perused by the laser community.

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