Biological basis for analysis of lasers' action in infectious processes. Biofilm, Interaction of light with matter, pathophysiological aspects.

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The biotechnological advances in the contamination reduction have been studied since Maiman,1960. In fact one of the major difficulties in the use of lasers was the possibility of its actions lead to no effect on the underlying tissues, when dealing with infectious processes involving tissue.

In the history of the evolution of lasers, we observe that besides the correlated applicability be related to the action of a portion of light, called wavelengths, together with their respective chromophore (agent / substance interaction) there are mechanisms to modify this light through different engineering.

The light of high intensity lasers such as Erbium YAG, CO2 and Nd YAG could be coupled with systems to allow an interruption of the light beam, generating a thermal relaxation zone. Some lasers still engaged in this external irrigation system that, together with a precise specific protocol, allows the target cell to be irradiated without causing thermal damage to surrounding tissue remnants.

The beam delivery systems, which can be of various shapes, can interfere with the final answer. This should be one explanation for the diverse protocols proposed in various articles.

The laser light which is characterized by its coherence, polarization, and a specific wavelength must be analyzed through the action of its wavelength and also specific substances. The different wavelengths may have similar substances, in a matter of affinity. The analysis of the different strengths of this affinity is interesting to defining the best type of laser for your procedure. For example: the erbium laser shows excellent affinity for water and, even if the CO2 also has this affinity, your system and their affinity for other elements result in a different action. The erbium laser typically presents ablation of tissues and cells when the CO2 laser is known for its vaporization of tissue features, creating what some authors call biological cement.

When we aim the decontamination, tissue healing, and the recovery of the affected area, the observation of different means of interaction as the pathophysiology of the lesions was directly related to therapeutic success.

Lesions in the oral cavidae usually are conditioned to a specific formation of biofilm. Bacteria in this biofilm cluster so that aerobic microorganisms gram positive protect gram negative anaerobes. Particularly some diseases related to periodontal would be conditioned to a reduction of individual resistance and changes of neutrophils. Cofactors exist and aggravate this picture, such as: metabolic changes related to emotional state of the patient, mielitus diabetes, hormonal disorders, medication use, among others. This sets an interesting aspect about protocols proposed to service with the use of laser.

Some authors were using the photodinamic therapy for local decontamination in periodontal pockets. In recent literature review, the results inirentes the treatment of low-intensity lasers with specific chromophores applied on the affected area by periodontal disease were positive. Specifically regarding its role in gram-negative bacteria, the possibility of direct action was questioned, then, with the individual disability possibly conditioned by genetic factors, aiming at a faster and more efficient control of the process, the antibiotic supplement therapy is recommended.

We can enumerate other aspects given the use of laser light: acceleration of the healing process, organization of new fibers by light polarization, and increased tissue resistence related to the biomolecular aspect, already studied in literature. A residual analysis for the reduction of the use of conventional antibiotics and control of bacterial resistance, the effect ablation of tissue seems to fit in a superior manner.

The protocol with the use of erbium yag will be proposed and discussed based on the biodynamic of the periodontal disease, individual variables, control and balance of local biodynamics.

Keywords Erbium YAG action; Periodontal disease; Interaction of light; Biofilm; Laser; Periodontal treatment

1. Biofilm -Periodontal disease - Periimplantitis

Costerton et al, 1995, described about biofilm. Some of their conclusions:

- Metabolism will have varying effects based on the location of the microbe in the biofilm.
- Based on thousands of serial optical snapshots of these biofilms and the aforementioned probes and physiologic measures, a conceptual model of a microbial biofilm has been proposed. An in vitro grown biofilm is composed of mushroom-shaped towers or pedestals of biofilm with water channels being a very prominent feature of the biofilm structure.
- Penetration of antimicrobial agents into the centers of these towers is highly limited, effectively protecting the biofilm microbes in these locations under certain conditions (circumstances), streamers of biofilm cells development, particularly under flowing conditions, and these can break off, resulting in detached micro colonies of bacteria that can be carried to distant locations to colonize a new surface.
- The water channels facilitate the rapid movement of materials throughout the biofilm, but penetration into central regions of the mushroom-shaped towers is much more restricted.

The same authors have suggested in 1999 that these micro channels were analogous to blood capillary beds in tissues of higher organisms.

Davies et all, 1998, Van Delden, and Iglewsk studied communication system in biofilm in 1998 and demonstrated that bacterial cell in biofilm occur with one another using specific cell-to-cell signaling molecules. The communication with host eukaryotic cells is the responsible of biofilm associated problems.

It was also described about the same microbial composition and the host material, and the difference between biofilms as they studied in vitro and in vivo.

"Host –derived biofilm components can interact with antimicrobial agents, resulting in a reduced activity or conflict inactivation. The microbes themselves in a biofilm may produce specific enzymes that results in inactivation of a disinfectant."

- Technology was described by Cery et all, 1999, and that is necessary new methods of control, prevention, and removal.

Consterton, 2002, noted the relevance of biofilm associated with periodontal disease, as well as several authors have reported colonization by implanted devices with the same flora. Regarding periimplantitis as a titanium screw is inserted in place of the loss of a tooth, the same device may change in surface, and this alteration can lead to adjacent bone loss, leading to loss of the implanted device.

The colonization of biofilm seems to be the major cause of tooth loss and implanted elements.

Some studies in the area of implantology involve preventive mechanisms, including protocols for performance with different types of implants, targeting an adjacent tissue with greater predictability, protecting the device. Within these possibilities we can be covering not only the possibility of a thicker surrounding tissue as the amount of bone and gum tissue will be responsible for organizing differential function of local metabolism, but also the use of dental implants in inverted platform and using the same Cone Morse engineering taper implant devices. Given that both result in a long-term maintenance of the surrounding bone. The inverted platform is limited with respect to the bone amount insufficient. The cone-morse technology has higher adaption with a virtual gap, avoiding colonization in this region. The inverted plataform or Switched Plataform was well studied in 2011. Almeida described about this important protocol to protect and avoid contamination of implanted area.

2. Laser

Lasers can be classified as Low intensity and High intensity.
We can also describe different effects:

HIGHT INTENSITY LEVEL LASER

- Ablation Effect
- Vaporization Effect
- Photothermolysis effects

LOW INTENSITY LEVEL LASER

- Bioestimulation Effect
- Anti-inflammatory Effect
- Photodynamic Therapy

Described by Alora, 2000, the use of lasers or laser surgery seems to be the most rapidly advancing fields in health area. In dermatology and ophthalmology, lasers are responsible for the most precise form of surgery.

The same study described:

- The theory of selective photothermolysis, introduced by Anderson and Parrish, in 1981, is the bases for several advancements in dermatological lasers. To achieve selective photothermolysis, appropriate wavelength, exposure duration, and sufficient fluency are necessary. This procedure was used in dermatology process, and allows for highly localized destruction of light-absorbing "targets" in skin, with minimal damage to the surrounding tissue.

In 1989, Walsh, Flotte and Deustsch described Q-swiched pulses to reduce thermal damage. Today the new technology is responsible of no thermal damage.

- Exposure duration should be shorter than or about equal to the thermal relation time of the target.
- Thermal relation time is the time it takes the target to cool significantly and is proportional to the square of the diameter or the target. Therefore, the thermal relation time of a small object is much shorter than that of large objects.

"The thermal relation time in seconds of a target is equal to the square of its diameter in millimeters. Thus a 0.1 mm blood vessel cools significantly in about 0.01sec (10msec)."

"Sufficient energy must be delivered to cause the desired effect, destruction of the target."

Fluency (energy/area), necessary energy for treatment, is inversely proportional to the fraction of light absorbed at the targets.

Alora, 2000, mentioned that if the chromofore is less absorbed in a timer, it is possible to use a higher fluency. It is also possible to use the same method to the targets that are deep within the skin. And a classic example of selective photothermolysis is the use of pulsed lasers in the treatment of port- wire stairs (PNS). PNS consists of dilated venules in wich the principal chomophore is oxihemoglobine.

2.1. Absortion /Chromofore

Alora, 2000, also described about chomofore. Important points:

- Oxyhemoglobin and reduced hemoglobin have wide but useful absorption hands in the near-infrared spectrum (700-1200 nm), also Nd:YAG lasers that emit laser light at 1,064 nm can penetrate deeper and is useful for veins.
- The Carbon dioxide laser, 10.600 nm wavelength, because of its strong absorption by water was the most used on dermatology. Also leave 0.2-1mm of residual thermal damage, which depends on laser exposure. Because of its mechanisms of delivery it is not possible to control the effects that result in biological cement.
- The residual thermal damage from CO2 lasers may be minimized, using pulses that are shorter than the thermal relaxing time or using it with faster movements (reducing the time exposure).
- The ER:YAG laser, emission wavelength of 2940 nm is the most strongly absorbed of any wavelength by water, 16 times greater than CO2 laser light and a 1 μm penetration versus 20 μm for CO2.

2.2. Laser treatment / Antimicrobial treatment

Wellman, Fortun and Mcleod in 1996, described that bacteria that have formed into biofilms on medical devices present major problems, since these biofilms shows greatly increased resistance to antimicrobial chemotherapy, the primary treatment for internal, medical device-related infections. Previous research indicates that in order for esterilants and antibiotics to be effective against biofilm bacteria, concentrations from 500 to 5,000 times greater than those required for killing planktonic (floating) strains of the same bacterial species are necessary. At these extremely high antibiotic levels, it becomes impossible to safely treat patients with internal medical device infections with antibiotics only.

Based on Yilmaz et al, 2010, and Freitas, 2004, (internet zone – www.fernandafreitas.com.br), two protocols with ER:YAG laser were proposed.

Both authors talked about the benefits of the laser light as a better resolution for periodontal infection combined with SRP. Besides the comparison of the SRP with or without systemic metronidazole, treatment with laser can be a special tool to have this kind of biofilm controlled in a faster way. Dyer, 2012 also proposed another protocol.

Yilmaz Protocol:
Er:YAG laser - 10 Hz, 30 mJ/pulse, 1min/poket, apico-coronal direction in parallel paths with 30 degree angle tips, under water irrigation

Freitas Protocol:
Er:YAG laser – 6Hz, 180mJ/pulse, 0.5 to 1mm/sec movement, apico-coronal, Kavo Key laser II, cristal tip, under water irrigation
Micro flaps – 250 mJ/pulse, 10 Hz – 5 mm or > pockets.

Dyer Protocol:
Er,Cr:YSGG Laser – 30hz, 16.99J/cm², 1.0 Fluence, water spray 20% and 11% air. MZ type tip/ diameter 500 microns and 14 mm in length.

As Yilmaz described, the primary objective of mechanical periodontal treatment is to disrupt subgingival biofilm and remove bacterial deposits from root surfaces, in an effort to stop tissue destruction, and eliminate or control etiologic agents, together with creating a microbial shift toward what is typically present in health.

One of the most troublesome processes is the deep pockets control. Some authors report the use of combined therapy. Amoxicilin and metronidazole seems to be the most effective way (Sgolastra el al, 2012) (Casarin et al,,2012). In the past, the elimination of the pocket (the affected tissue) with surgery was common. Now, some other authors combined SRP and micro flaps to permit better access of eliminating bacterial deposits and prepare better the root surface. In fact, some microorganisms are affected when exposed to oxygen. Pockets with 6 mm or higher are better controlled with flap surgery. Beside, Feres, 2004, described that this periodontal pathogens seems to not act alone and interactions between species, especially the balance between pathogenic and beneficial species which affect both the progression of disease and the response of tissues to periodontal therapy. In 1992 the host response was investigated by Genco but the same author agree that it is not only about the host.

The organizational capacity of the ecosystem itself microorganisms and its perfect composition due to the maintenance of the group seems to be evidenced in the current studies.(Li and Tian, 2012). After identification with the territory the species cluster aiming strength and adaptation. In the oral cavity seems to resonate this biosystem as a causal factor of periodontal disease aggravated by individual susceptibility or immunity. Kinane, Preshow and Loos described the importance of PMNs but showed the complexity of the role of cytokines. Keer, 1999, describes eukaryotic cell adhesion molecules in host defense otherwise are involved in pathogenic effects of some microorganisms including *Actinobacillus actinomycetemcomitans, Sthaphylococcus aureus, Streptococcus pyogenes.*

Otomo-Corgel, 2012, and Kamer, 2008, described association of inflamatory periodontal diseases with multiple systemic conditions. These diseases seems to be controlled adjunctive with oral health.

The laser adjunctively with conventional tools results in improvements in the healing process.
The healing effects are also observed in low laser therapy, other effect also occurs like vasodilation. Some of these lasers are at red and infrared wavelengths. These lasers combined with an external chromophore can be used to reduce microorganisms. As Gjourup review, Gursoy et al also described this therapy in a positive way, but Gursoy agrees with Freitas cited in Gjourup review and internet zone, PDT (Photodynamic Therapy) cannot replace antimicrobial therapy at this current stage.

3. Conclusion

The biothechnology is a real instrument to help us on biofilm control. It is very important to have a good knowhow and use the tool as an additional instrument. The Erbium laser is the best choice when periodontal biofilm has to be eliminated. Its water absorption can explain the efficiency of the therapy.

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