Dental lasers for soft tissue surgery and periodontics

What we know and what we've learned

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_About 1975 medical surgeons began using a new device that complemented and, in some cases, replaced the scalpel. That instrument was a laser, and during the 1980's a Carbon Dioxide model was a common component in the operating suite. In 1989 the first laser specifically designed for dental use became available. Today there are two dozen indications for use with various dental laser devices; and the clinical applications continue to increase, making the laser one of dentistry's most exciting advances with unique patient benefits. This article will attempt to summarize those laser applications for dental soft tissue and treatment of periodontal disease.

Surgical lasers produce energy that can be absorbed by a target tissue, and this absorption proceeds as a photo-thermal reaction; that is the radiation produces a thermal reaction in that tissue. While other effects are possible, including true photo-disruption where molecular bonds are broken without vaporization to very low level use of laser energy producing a bio-stimulatory or bio-modulation effect.[1] Depending on the instrument's parameters and the optical properties of the tissue, the temperature will rise and various effects will occur. In general, most non-sporulating bacteria, including anaerobes, are readily deactivated at temperatures of 50 °C.[2] Proteins begin to denature at temperatures of approximately 60 °C without any vaporization of the underlying tissue.[3] This is a clinically useful effect because, if the temperature can be controlled, diseased granulomatous tissue will be removed while the biologically healthy portion can remain intact. Coagulation, also occurring at this temperature, refers to the irreversible damage to tissue, congealing liquid into a soft semi-solid mass.[4] This process produces the desirable effect of hemostasis, by the contraction of the wall of the vessel. At 70 to 80 °C uniform heating will produce adherence of the layers because of stickiness due to the collagen molecule's helical unfolding and intertwining with adjacent segments, a process sometimes termed tissue welding.[5]

Laser excisional or incisional surgery is accomplished at 100 °C, where vaporization of intra- and extracellular water causes ablation or removal of biological tissue.[6] Thus excision of soft tissue can begin at this temperature, but the apatite crystals in dental hard tissue will not be ablated. However water molecules dispersed throughout mineral structure are vaporized and the resulting jet of steam expands and then explodes, removing the tooth structure. This water mediated explosive removal transfers minimal heat to the adjacent tissue.[7] Thus, cavity preparation, calculus removal, and osseous contouring can proceed.

Continued application of energy will raise the tissue temperature. At about 200 °C dehydration is complete and the tissue carbonizes. Carbon as the end product absorbs all wavelengths. Thus, if laser energy continues to be applied, the surface carbonized layer absorbs the incident beam, becom-

Fig. 1_Immediate post operative view of an Nd:YAG laser gingivectomy, using high power.
Fig. 2_Seven month post operative view with final restorations in place.
Fig. 3_Immediate post operative view of another gingivectomy using a newer laser with less power and better technique.
Fig. 4_One week post operative view at the restoration try-in appointment. Note tissue healing.

Fig. 1

Fig. 2

Fig. 3

Fig. 4

ing a heat sink. Collateral thermal damage can spread rapidly preventing normal tissue ablation and causing tissue necrosis.[8]

Some of the general benefits of the use of lasers in dental soft tissue include:

_Lasers reduce pathogens
_Lasers provide hemostasis
_Lasers can offer better post operative courses in healing
_Lasers can offer biostimulatory effects
_Lasers can have advantages over scalpels and electrosurgery.

For pathogen reduction several studies point out that every wavelength is effective, which is clearly a different effect than when a scalpel is used.[9-12] Moreover there is an advantage in reduce the need for prescription antimicrobials for a wide range of patients including children and pregnant women. Additionally, without medications, the patient will not experience allergic reactions, bacterial resistance or untoward side effects.

The ability to control bleeding during surgery enables much better visualization of the area. Some wavelengths achieve better hemostasis than others. The erbium family whose radiation is emitted in a free running pulse mode offers less sustained energy so soft tissue surgery may not be totally bloodless.[13-16] There are some conflicting results from studies comparing the post operative healing from lasers versus other modalities. Some authors point out that the healing can be faster, slower or the same as conventional instrumentation.[17-21] At the same time lasers have been shown to have offer bio-stimulatory effects. These are not clearly understood, but are clinically significant during and after treatment, adding to the value of health care.[22-23]

Other advantages include the lessening need for sutures[24], less painful treatment and reduced swelling post-operatively[25], less wound contraction[26], easier contouring of gingival tissues compared to a scalpel[27], safer around dental implants[28], and generally better patient acceptance of a procedure[29].

For treatment of periodontal disease, once again all wavelengths show usefulness. After scaling of the root surface with other instrumentation diode, Nd:YAG and Carbon Dioxide lasers are used can be used on the soft tissue side of the periodontal pocket to remove the inflamed soft tissue and to reduce the pathogens.[30-34] The erbium family of lasers can also be employed to remove calculus and other accretions on cementum with results similar or better than conventional scalers.[35-37]

The first twenty years of dental laser technology have been accompanied by sophistications in the instruments themselves, as well as improved surgical techniques. Figure 1 shows one of the author's first cases of gingival contouring in an immediate post-operative view and Figure 2 shows the restorations in place several months later with good tissue health. Retrospectively the soft tissue in the first figure received an excessive amount of laser power, as evidenced by the dark and almost charred areas; however, the healing progressed with a beneficial result. The immediate post-operative consequence of the author's use of a newer pulsed instrument with much more controlled thermal interaction is shown in Figure 3. Figure 4 illustrates the trial fitting of the restorations with the tissue practically healed. The conclusion to be drawn from these two cases is that the surgeon must observe the photothermal events carefully and employ proper instrument parameters.

In summary although lasers cannot totally replace conventional instrumentation, the overwhelming evidence from published studies and clinical cases provide assurance that lasers are a beneficial treatment modality for dentistry._

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