Introduction

Lasers in the healthcare industry have seen a dramatic increase in the past few years, from their commonplace use in ophthalmology, dermatology and plastic surgery.

Patients have adopted the medical application branding as safe and effective. In addition, the increased trend of microinvasive procedures has led to the laser’s acceptance. Many patients desire quick procedures with the expectation of uneventful healing and minimal disruption in their lives.1

The utilization of lasers in the dental profession is increasing because of improved training and education. Enhanced, dependable technology with these devices creates a user-friendly environment with procedural presets and accompanying graphics, and the affordability has resulted in increasing accessibility.2

Along with acceptance, there has been a broadening of laser dental indications, including procedures for direct restorative therapy and, indirectly, to enhance restorative dentistry. While consideration for lasers in periodontal management has been suggested for several years, its exact role has been complicated and confused until recently.

Periodontal disease

For decades, the focus on managing periodontal disease has primarily been from an antimicrobial direction.

Inclusion into periodontal therapy from a nonsurgical vein has centered on mechanical and chemical warfare against the primary etiology, such as the microbial flora. And while we wouldn’t discount bacterial pathogens as the primary stimulus, the role of the host response in the form of a chronic inflammatory reaction has balanced out the pathogenesis story.

A new paradigm is evolving to include anti-inflammatory and host modulation systems to manage the periodontal patient.3 Any new device or protocol should incorporate both antimicrobial and anti-inflammatory concepts.

Current systems to manage periodontal disease have improved significantly, using the chemical and mechanical approach. We now have at our disposal the augmentation materials to engender regeneration through wound healing.4 However, these systems have been limited in the past because of factors such as high cost of use and patient perception of related outcomes or potential discomfort.

Dental laser wavelengths and respective tissue targets

Lasers have the ability to affect tissue depending on the nature of the target. By using a coherent light beam, energy is directed through an electromagnetic wave, generally through a process noted as ablation (vaporization). This thermal radiation is
nonionizing in a range of 350–10,600 nanometers. The radiation is considered safe to human cells when used with the appropriate settings and precautions.

The action of a laser is photo-thermal by absorption into the appropriate target. When a laser is aimed at any target, the energy is reflected, scattered, transmitted or, ideally, absorbed (Fig. 1).

Dental lasers can be divided based on their actions on soft tissue, hard tissue or both. The respective wavelength is absorbed by the appropriate tissue.

For soft tissue, the chromophore target is hemoglobin, melanin and water in cells. Diode and Nd:YAG lasers are very effective on soft tissue because of their short absorption coefficients and how they see hemoglobin, pigment and, to a limited degree, water.

For hard tissue, the primary chromophore is water in cells and carbonated hydroxyapatite. Erbium (Er,Cr:YSGG and Er:YAG) and CO₂ lasers are indicated for hard tissue and, to a degree, some soft tissue because of their long absorption coefficients and affinity for these targets.

Diode and Nd:YAG lasers are contraindicated for hard tissue and can create adverse thermal effects on these surfaces. Erbium and CO₂ lasers are considered all-tissue lasers. Below is a summary breakdown.

**Dental laser wavelengths and their targets**

<table>
<thead>
<tr>
<th>Laser</th>
<th>Soft tissue</th>
<th>Hard tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Diode</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Erbium</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Nd:YAG</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

**Ideal qualities of a periodontal laser**

Specific tenets have been developed as ideal components of any laser protocol in managing periodontitis. These characteristics are essential, irrespective of a technique, material, or pharmacologic product or device.

While few entities could satisfy all, the ideal laser system should incorporate most of the core indications in managing periodontal disease.

**Antimicrobial effect:** Laser energy can have a significant effect on the microbial flora via denaturation of the cell walls; thermal effect by the attraction to pigment in the cells of specific microorganisms such as Porphyromonas gingivalis; and a direct thermal heat effect. All dental laser wavelengths have at least one of these properties. However, a question remains with any antimicrobial technique. Can one completely sterilize a sulcular environment to avoid recolonization?

**Sulcular debridement:** Removal of necrotic tissue that may contain inflammatory components, such as hyperactive neutrophils, enhances eventual wound healing. Removal of the epithelial lining
in the sulcus (and possibly external to the sulcus) stifles epithelial migration, which can assist in new attachment\(^6\) (Fig. 2).

**Root decontamination:** Root surfaces must be devoid of calculus and endotoxin. A root detoxification process is essential. And removal of the smear layer becomes important if one considers a positive environment of fibroblast adherence\(^7\) (Fig. 3).

**Attachment via wound healing:** Laser energy should promote regeneration of the periodontium’s components, including connective tissue attachment, cementum, periodontal ligament and osseous structures.\(^8\)

### Periodontal patient indications

Data collection is essential to determine a diagnosis that includes reliable and valid periodontal probing, quality radiographs, furcation detection, attached gingivae measurements and mobility indicators. This data transforms into a diagnosis and ultimately a prognosis and treatment plan.

Not to overly simplify the process, but patients can be moved into two broad categories: nonsurgical and surgical (Table 1).

### Matching laser wavelengths with periodontal patients

Nonsurgical periodontal procedures can be performed with all dental lasers. Soft-tissue lasers, such as the diode and Nd:YAG, are especially indicated for periodontal debridement procedures. These laser wavelengths have the ability to create an antimicrobial environment with their attraction to pigmented microorganisms.

Their thermal properties allow for sulcular debridement by removing the necrotic tissue. Some protocols suggest multiple appointments, with frequent de-epithelialization after the initial procedure to inhibit epithelial downgrowth. While in theory there appears to be a rationale, the practicality of a patient returning frequently limits having any laser effect on the root itself. Therefore, root decontamination would require additional conventional instrumentation, such as power-driven ultrasonics or manual devices.

of the diode and Nd:YAG is the ability to improve hemostasis, which also creates a positive access environment.

Hard-tissue lasers such as the Erbium (Er,Cr:YSGG and Er:YAG) and CO\(_2\) have the properties that help manage early periodontitis. Not only do they provide the ability to be antimicrobial and provide sulcular debridement, but they also assist in removing calculus and detoxifying roots.

Note that CO\(_2\) lasers must have the property of being superpulsed or the energy will have adverse thermal changes on roots. These lasers are not utilized as much as diode lasers, because they’re cost-prohibitive in nonsurgical periodontics.

### Hard-tissue lasers

Hard-tissue lasers can perform surgical periodontal therapy. While they can have an antimicrobial effect and assist in sulcular decontamination, their attraction to hydroxyl apatite is a major asset in root detoxification, calculus removal and osseous surgery. They have the ability to remove the smear layer by opening the dentinal tubules, thus enhancing fibroblast attachment.\(^9\)

Erbium lasers are considered the most versatile laser in periodontics because they can seek both hard and soft tissue targets of the periodontium with no adverse sequelae. They have the ability to also create a decor- tication environment whereby the cancellous bone has an opportunity to release bone morphogenetic protein.

The ability of hard-tissue lasers to affect

| Patient conditions that are indications for surgical/nonsurgical procedures: |
|-------------------------------------------------|-----------------|-----------------|
| Nonsurgical                                      | Surgical        |
| Periodontitis:                                   |                 |
| Early                                           | Moderate to severe |
| Pocket depths:                                  |                 |
| 4–5mm                                           | > 5mm           |
| Local factors:                                  |                 |
| Evident as subgingival calculus                  | Minimal         |
| Teeth:                                          |                 |
| Single-rooted, more predictable                  | Multirooted, with furcation involvement |
| Bone:                                           |                 |
| Horozontal bone resorption                      | Angular boney topography |
| Compliance:                                     |                 |
| Noncompliance a concern                         | Good patient compliance |
| Management:                                     |                 |
| Periodontal debridement                         | Surgical intervention |
| (scaling and root planning/gingival debridement) |                 |

Table 1

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all tissues gives rise to positive wound healing and associated regeneration via granulation tissue removal, release of blood and associated biomodifiers.

Diode and Nd:YAG lasers conceivably can be used in surgical periodontal procedures; however, the steps would be limited to only soft-tissue components of the overall procedure, with additional required steps utilizing traditional modalities as ultrasonic and manual devices for decortication.

The attraction to lasers in periodontal care is that most devices have tips that are thin in diameter for sulcus access (Fig. 4). This affords closed-flap approaches to accessing the periodontium. Laser handpieces are small in diameter and can be manipulated into inaccessible areas in the oral cavity, especially in the posterior quadrants. Handpieces can also have light, air and water, which aid in visualization and cavitation.

**Biostimulation**

The process of photobiomodulation creates a positive wound healing and anti-inflammatory environment.

While all lasers have some biostimulatory effect, lasers utilized in this category are generally in the 630–980nm wavelength category. The healing stimulates the mitochondria and releases ATPs. Clinicians primarily use biostimulation with diode lasers immediately after both nonsurgical and surgical procedures. The most significant effect happens when there is an increased frequency of application. Studies do demonstrate favorable wound healing with biostimulation.11

**Safety considerations**

As with any device or procedure, adequate training for competency is required. Certification programs as sponsored by the Academy of Laser Dentistry are comprehensive for in-depth knowledge base and instruction of today’s dental laser usage.

Dental offices that use lasers should have an assigned laser safety officer to ensure the safe, effective use of the device with patients. Appropriate safety eyewear for the respective wavelength is mandatory, as is appropriate signage during laser use. High-volume suction is essential to avoid the laser plume generated from laser activity on the respective target.

**Conclusions**

Minimal contraindications exist for dental lasers when the practitioner has acquired an in-depth patient medical and dental history and has a sound understanding of the respective laser.

The clinician must appreciate that laser energy is quite different from traditional mechanical energy. However, with the appropriate application, the dental laser has far-reaching potential in managing periodontal patients. With our expanding knowledge of inflammation, wound healing and regeneration, the laser appears to be a device with significant opportunity (Figs. 5a & 5b). Moreover, patients desire not only acceptable clinical benefits but outcomes with reduced discomfort and an overall positive effect to their lifestyle. Lasers appear to be moving rapidly into the desired minimally invasive concept and can be considered as a mainstream adjunct in the near future.

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**References**