Lasers in Implant Dentistry, Part 1

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Lasers in Implant Dentistry, Part 1

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About the Author

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In the past, some in the profession have questioned whether lasers are a legitimate adjunctive tool for dentistry, or an application looking for a purpose. Lasers have been slower to gain relevance in our profession, whereas they are more commonly accepted as staples in the medical profession for such areas as laser eye surgery; ear, nose, and throat surgery; dermatology; and urology. The development of the use of lasers in dentistry has grown in the last 5 to 6 years with the release of soft-tissue diode lasers which were cost effective, portable, lightweight, and reliable. Suddenly, many clinicians began looking to replace their aging electrosurge units with diode lasers. The growth of diode lasers as soft-tissue handpieces evolved, in part due to their ability to work safely with pacemakers, and their usefulness in being able to be used around implants, crowns, amalgams, and other metal substructures while minimizing the risk of creating iatrogenic damage. In addition, a laser’s ability to be used within endodontic canals and periodontal pockets to decrease bacteria, and for their capability in being able to remove small amounts of tissue with only topical anesthetic, made them increasingly popular amongst many dentists. All of these advantages led to the popularity of diode lasers as an alternative to electrosurgical units worldwide.

Nd:YAG and carbon dioxide (CO₂) lasers were the first soft-tissue laser wavelengths introduced in dentistry in the early 1990s. Diode lasers, first introduced in 1995 for soft-tissue procedures, have impacted many areas of our dental practice, including gingivectomies, as an alternative to retraction cord in tissue management for crown and bridge, for soft-tissue surgeries such as frenectomies and fibroma removal, and for the treatment of vascular lesions such as venous lakes (hemangiomas) (Figures 1 to 3).

The erbium family of hard-tissue lasers (Er,Cr:YSGG and Er:YAG wavelengths) made their appearance in dentistry in the late 1990s and were heralded initially for their ability to cut tooth structure as well as soft tissue. The ability to ablate anything with water in it made it possible to use these “all-tissue” lasers for many purposes, including local anesthetic-free restorations, the removal of porcelain veneers, and all-ceramic porcelain restorations in an efficient, safe, and predictable manner. In addition, the erbium family of lasers can be used to remove bone for crown lengthening procedures and have been promoted for their abilities in the field of endodontics to help with deep disinfection in the dentinal tubules through their antibacterial capabilities. More recently, the Er:YAG laser has been promoted for its role in periodontics as it possesses suitable characteristics for the effective elimination of granulation tissue, gingival melanin pigmentation, and gingival discoloration. Furthermore, the cutting and contouring of bone with minimal damage and even faster healing can also be performed with this laser. Erbium lasers are antibacterial and can remove both calculus and biofilm around tooth structure and implant surfaces.

LASERS IN IMPLANTOLOGY

The role of lasers in dental implantology was explored by Romanos et al. and they found that soft-tissue lasers could be of benefit for improvements in hemostasis, as an adjunct to soft-tissue peri-implant recontouring, and for improving wound healing. Hard-tissue lasers (Er:Cr:YSGG and Er:YAG wavelengths) were valuable for laser-assisted osteotomies, and for the improvement in early osseointegration after fixture placement. They also mentioned that lasers could be used for the treatment of peri-implantitis.

Although it is difficult to categorize the role of lasers for implantology, one method to do so has been developed by the
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![Figure 1. Pre-op old veneers requiring replacement due to caries and discoloration.](image1)

![Figure 2. Diode laser crown troughing and frenectomy.](image2)

![Figure 3. Two-week postoperative healing of final results.](image3)

The author of this article and looks at the role of lasers by the timing or stage of the procedure (Figure 4). This method of categorizing the role of lasers looks primarily at the benefit at a certain stage of the implant treatment cycle. Effective use of laser energy can be beneficial at all stages of implantology, from prior to implant placement where lasers can be used to remove bacteria and granulation tissue, to during the procedure for flap incision, decortication, and ablation of excess soft tissue or bone. After-implant placement lasers can be beneficial for uncovering and soft-tissue recontouring during the prosthetic phase. Finally, lasers are gaining an exciting and important role in the growing issue of peri-implantitis and mucositis during the healing phase.

In the first of this 2-part article series, I will look at the role of lasers prior to, during, and immediately after implant placement in Stage 1—the surgical portion of the procedure. Part 2 will discuss the role of lasers after the initial implant surgery and look at the role of lasers for uncovering, cementation, and in the growing role of lasers for the treatment of peri-implantitis.

### Laser Usage Prior to Implant Placement

At times, a tooth becomes unsalvageable due to restorative, endodontic, or periodontal concerns, or a combination of these factors. Despite heroic attempts, teeth must be at times extracted, and grafting of the site for preservation of hard and soft tissue must be undertaken in order to replace missing teeth with dental implants. Kusek39 showed that the use of an erbium laser, through photoacoustic streaming, could reduce the bacteria in osteotomy sites that were infected by apical pathology. The author39 took swabs both immediately after extracting teeth and subsequently again after the Er,Cr:YSGG laser was used. The results showed a noticeable reduction of bacteria and no traces of virulent bacteria.

With the use of the BİOLSE iPlus (Er,Cr:YSGG wavelength), the laser can effectively and safely interact with soft tissue to remove granulation tissue and, in addition, can disinfect the extraction socket without fear of damage to bone prior to socket preservation procedures (Figures 5 to 10). The effective use of radially firing tips where 85% of the energy (Figure 11 to 13) fires laterally, combined with the microexplosive cavitation caused by rapid expansion of water particles when the laser wavelength interacts with water, allow for tremendous disinfection and cleaning of the infected extraction socket for prior to the socket grafting procedure.

All lasers are antibacterial in nature and can be used to varying degrees to disinfect a site.31-32 Some soft-tissue lasers like diode lasers should be used with caution so as not to heat up the bone, but when used judiciously (power of one W or less continuous wave [CW], uninitiated tip), they can help disinfect a site prior to grafting. There is a growing issue worldwide with bacterial resistance to systemic antibiotics,33 and combined with the horrible taste of some of the antibiotics that can be combined with bone grafts (ie, clindamycin), lasers can help

<table>
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Erbium "all-tissue" lasers have been used to ablate bone for lateral sinus lifts in the past, but one must realize that the laser is not able to selectively ablate (cut) only bone. The laser energy is absorbed by water so both bone and soft tissue can be ablated. Piezo surgical units are not as likely to cut the sinus lining during their use and the speed of cut with the erbium laser is similar to that of the piezo units. Although lateral window sinus lifts can be successfully completed with erbium lasers and the fine mist of water spray can be beneficial to see the surgical field compared to a turbine motor with bur, magnification and caution must be employed when considering lasers in this procedure in order to prevent tearing of the Schneiderian sinus lining membrane.

**Laser Usage During Implant Fixture Placement**

Laser usage can be beneficial during the actual implant placement for creation of the flap incision, for the actual creation of the osteotomy, and for decortication for guided bone regeneration (GBR), amongst other items.

All lasers can ablate soft tissue and thus can be used to make incisions in soft tissue. The lasers offer great hemostasis compared to surgical blades, but do cut a larger incision in width due to their larger tip diameter. The wavelengths used vary in their depth of penetration into the tissue with some soft-
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tissue lasers such as diode lasers or Nd:YAG lasers penetrating further compared to CO₂ lasers. Typically, the lateral thermal damage for lasers is much smaller than for electro-surgery units, but the mechanism of action for soft-tissue diode lasers is thermal or infrared, which means that light is converted to heat and that is the primary method for ablation. Wavelengths that offer water as a cooling mechanism to the photothermal ablation (erbium lasers and the new CO₂ 9,300 nm wavelength) may allow for a decrease in unwanted thermal effects due to a low inflammatory response with minimal resulting damage to surrounding tissue.

One benefit of using the water-cooled erbium lasers is that the fine mist of air and water that is created helps keep the visual field clean and with very little bleeding when compared to a blade, and the reduction in inflammatory response allows laser incisions to be comparable to that from a surgical blade in many respects of healing.

Lasers that can ablate bone, such as erbium lasers, have been suggested as potentially capable of producing osteotomies in their entirety, with the benefit being superior bone-to-implant contact (BIC) and implant stability measurements at 8 weeks postoperatively. The laser-produced osteotomy was wider in many areas of the preparation than a drill osteotomy, but thermal damage to bone is not present in the laser-prepared osteotomies. The concern is that similar to using the erbium laser for a lateral sinus window, the speed is slow compared to a bur, the depth of penetration of the laser energy into surrounding tissues may be minimal, but the inability of the laser to selectively cut only bone can be an issue if working around key anatomical structures such as nerves and blood vessels, where unintentional ablation might lead to severe short- and long-term complications of paresthesia or hemorrhage.

The greatest benefit for using erbium lasers might be during the initial osteotomy guide hole, where burs might “slip” or “bounce” off irregular or sloped bony surfaces often seen during immediate implant procedures after extractions. The ability of the erbium laser to create precise starting points for the rest of the osteotomy in a noncontact fashion can be of benefit in many instances.

It has been said that implant dentistry is a prosthetic-driven procedure with a surgical component. In other words, the decision of where to place the implant is formulated by where the teeth should be ideally positioned, and not where the underlying bone is presently located. GBR has become an accepted procedure in our profession to create adequate bone for an area if it is deficient in either horizontal or vertical directions. Four basic tenets must be followed for the creation of new bone: primary closure of the wound to promote undisturbed and uninterrupted healing; angiogenesis to provide necessary blood supply and undifferentiated mesenchymal cells; space creation and maintenance to facilitate space for bone in-growth; and, the stability of the wound to induce blood clot formation, allowing uneventful healing.

To create angiogenesis, most clinicians will use a round bur to perforate the cortical plate to allow for the release of progenitor cells. An all-tissue laser (erbium family of lasers) can also be utilized to decorticate the bone, and research has shown that there might be advantages to using the laser compared to a bur. Kesler et al. showed that the Er:YAG laser created higher levels of platelet-derived growth factor compared to a bur, and they proposed therefore that laser irradiation would likely enhance and improve the early healing of bone grafted areas when used for decortication.

Although prolonged use of soft-tissue laser wavelengths can be damaging to bone, the hard-tissue erbium lasers, due to their...
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water cooling spray, are safe to use on bone.\textsuperscript{47-49} The Er:YAG and Er,Cr:YSGG lasers provide precise ablation of bone with minimal thermal damage that makes them suitable for implantology. The ability to ablate precisely in noncontact fashion with lasers, and without the vibrations that are felt by the patient when using burs, these wavelengths (2,780 and 2,940 nm) are wonderful for GBR (Figures 14 to 17).

\textbf{Laser Usage After Implant Fixture Placement}

After the implant fixture has been placed, minor alterations in hard tissue may be needed if the bone is not level around the implant. At times, uneven bone, or sloped overhanging bone may prevent ideal and complete seating of the healing abutment in a single-stage procedure, and in addition, the potential of bone to prevent ideal impression taking, seating of the implant, or final restoration can create chronic discomfort, inflammation, or swelling of the final implant restoration. Erbium lasers, again due to their ability to precisely and safely remove bone, can be used at this time to relieve bone for ideal placement of prosthetic components such as the healing abutment. Research has shown that the erbium family of lasers will not damage the implant itself or cause untoward temperature increases in the surgical site that could jeopardize the implant itself (Figure 18).\textsuperscript{50,51}

In addition to ideal hard-tissue contours around the implants, the erbium laser can be safely used to trim soft tissue around healing abutments. When adequate soft tissue exists but the clinician wishes to produce a more ideal emergence profile, it can be desirable to choose a larger-diameter healing cap than the implant fixture diameter. At times it can be difficult to gain ideal closure of the flap. In these situations, minor soft-tissue refinement can provide a much improved closure around the healing abutment. It is important to recognize that adequate attached tissue that is keratinized must envelop the implant, so care must be taken to ensure that soft-tissue volume and adequate attached tissue exists prior to its removal (Figure 19).

The value of low levels of laser therapeutical energy (LLLT) has gained greater awareness in the last decade as research has grown on this topic. Although all laser wavelengths can provide some degree of biostimulation (wound healing) and bioinhibition (pain decrease), the most common wavelengths for these so-called “cold” or “soft” lasers is in the 655 to 810 nm range. Thus, diode lasers in the 810 nm range, when used at low energies (0.1 to 0.5 W CW) can be used for a variety of benefits for patients undergoing implant surgery. When laser energy is used for a therapeutic effect, a diffuse beam of energy size that is often larger in spot size (larger handpiece) is delivered to the tissue site over a period of time. The level of laser energy is low enough to have a therapeutic effect without causing any tissue destruction, and now a very common name for this procedure is laser phototherapy (Figure 20).

The mechanism of action for low levels of near-infrared laser energy to have either a biostimulatory or bioinhibitory effect lies in the energy being absorbed by cell mitochondria, which in turn produces a reactive oxygen species and releases nitric oxide in the cell. There is a corresponding increase in the release of ATP within the cell, and this leads to gene transcription that in turn causes the release of growth factors, cell proliferation, and cell motility with an increase in extracellular matrix. The result is that wound healing is improved through tissue repair, inflammation and edema are reduced, providing pain relief. Finally, neurogenic pain or
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problems can be lessened as well (Figure 21).

Although early pioneers in the realm of LLLT were dismissed, a great deal of research recently has shown value in using LLLT for implant therapy for many areas. A diode laser around 810 nm, when set to low levels of power, can be an effective modality for reducing postoperative pain and to promote wound healing after surgery.50 In addition, LLLT is highly effective for tissue repair and pain relief.51 Pinheiro et al52 showed that laser phototherapy provided SEM results that showed better bone healing after irradiation with the 830-nm diode laser, and concluded that LLLT may increase bone repair at early stages of healing. Other research53 has shown that LLLT promoted the osseointegration of implants with poor initial stability, particularly in the initial stages of bone healing and that using LLLT enhanced peri-implant bone repair, improving stability, BIC, and new bone formation when used every 48 hours for 2 weeks.54

One exciting area of research has looked at the reduction of neurogenic pain and sensory deficit when using LLLT. Unfortunately, neurosensory deficits can occur after any surgery, including implants either due to direct contact with a neurovascular bundle (ie, inferior alveolar nerve [IAN], mental nerve) with an implant, or through contact surgically with the anatomic structure. This can result in transient damage to an area of the skin or oral cavity. Traditionally, the clinician is asked to map out the area to “watch” and see how it heals. Unfortunately, patients want action, and the lasers can thus provide patients with a solution that often can be “felt” immediately with a significant decrease in neurosensory deficit and the visual analog scale analysis revealing progressive improvement throughout time.55 Other research concluded that LLLT is beneficial in patients with an IAN neurosensory deficit. In another study,56 it was seen that LLLT provided clinical effects on injured nerves that revealed an increase in nerve function and improved capacity for myelin production. So, using LLLT can be beneficial in many areas of wound healing and can provide potential options for problems that currently are not easy to resolve with traditional methods (Figure 22).

Figure 22. The mechanism of action for LLLT where near-infrared energy releases reactive oxygen species and releases nitric oxide, which leads to gene transcription and the release of growth factors, increased cell proliferation, and motility and a growth of extracellular matrix deposition. The result is a decrease in pain, inflammation, and neurosensory deficits.

In part one of this 2-part article series, I have attempted to look at how lasers can provide an adjunctive benefit to the early stages of implant therapy, namely adding benefits to socket grafting before the procedure, during the actual implant placement, and immediately after the surgery is complete. In part 2, we will see how lasers can be used during implant uncovering, during final prosthesis insertion, and for the exciting benefit of how lasers may provide a crucial role to the detoxification and disinfection of ailing and failing implants (peri-implantitis) where many currently used regimens fail to allow for reosseointegration of bone cells to the implant fixture.

Lasers are an application that has found its purpose in implantology, and hopefully with time, more clinicians will discover how vital laser dentistry can be to successful dental implantology.

CLOSING COMMENTS

In part one of this 2-part article series, I have attempted to look at how lasers can provide an adjunctive benefit to the early stages of implant therapy, namely adding benefits to socket grafting before the procedure, during the actual implant placement, and immediately after the surgery is complete. In

References

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1. The growth of diode lasers as soft-tissue handpieces evolved, in part due to their ability to work safely with pacemakers, and their usefulness in being able to be used around implants, crowns, amalgams, and other metal substructures while minimizing the risk of creating iatrogenic damage.
   a. True       b. False

2. The erbium family of hard-tissue lasers (Er, Cr:YSGG and Er:YAG wavelengths) made their appearance in dentistry in the late 1990s and were heralded initially for their ability to cut only tooth structure.
   a. True       b. False

3. The ability to ablate anything with water in it, made it possible to use these “all-tissue lasers” for the removal of porcelain veneers and all ceramic porcelain restorations in an efficient, safe and predictable manner.
   a. True       b. False

4. More recently, the Er:YAG laser has been promoted for its role in periodontics as it possesses suitable characteristics for the effective elimination of granulation tissue, gingival melanin pigmentation, and gingival discoloration.
   a. True       b. False

5. The role of lasers in dental implantology was explored by Romanos et al, and they mentioned that lasers could be used for the treatment of peri-implantitis.
   a. True       b. False

6. Kusek showed that the use of an erbium laser through photoacoustic streaming could reduce the bacteria in osteotomy sites that were infected by apical pathology.
   a. True       b. False
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7. Some lasers are not antibacterial in nature and cannot all be used to varying degrees to disinfect a site.
   a. True  b. False

8. All lasers can ablate soft tissue, and thus can be used to make incisions in soft tissue.
   a. True  b. False

9. The greatest benefit for using erbium lasers might be during the initial osteotomy guide hole, where burs might “slip” or “bounce” off irregular or sloped bony surfaces often seen during immediate implant procedures after extractions.
   a. True  b. False

10. The erbium laser cannot be safely used to trim soft tissue around healing abutments.
    a. True  b. False

11. The mechanism of action for low levels of near infrared laser energy to have either a biostimulatory or bioinhibitory effect lies in the energy being absorbed by cell mitochondria, which in turn produces a reactive oxygen species and releases nitric oxide in the cell.
    a. True  b. False

12. Studies have shown that low levels of laser therapeutical energy provided clinical effects on injured nerves that revealed an increase in nerve function and improved capacity for myelin production.
    a. True  b. False
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