From everyday dentistry to advanced photoacoustic endodontic applications (PIPS): Er:YAG & Nd:YAG dual wavelength laser

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I n t r o d u c t i o n

Lasers provide an exciting new tool that allows the dentist the ability to give patients optimal care without many of the “fear factors” found in conventional dental techniques. Used with proper understanding of lasers, lasers are extremely safe and effective. Using lasers for caries removal, post and core placement, endodontic treatment, bone management, cutting and shaping, and soft tissue procedures can reduce postoperative discomfort and infection, and provide safe, simple and predictable results. As we can improve our efficiency, expand what we can do, achieve better results and increase production.

Lasers represent a real quantum leap forward in the treatment of our patients, including the pediatric patient. The U.S. Food and Drug Administration (FDA) gave approval for the use of the Er:YAG laser in 1997 for both hard and soft tissue procedures. The erbium doped (erbium particles placed within the YAG crystal) crystal W1 is a diminuendo Garnier’s (Er:YAG) developmental and success has made the treatment of children safer and quicker.

Plainly stated, a laser is a piece of equipment that creates a concentrated monochromatic beam of visible or infrared light that can be absorbed by a specific target. Since then, laser-assisted dental care has changed forever: the way dentists can prepare diseased teeth, ablate bone and treat soft tissue diseases, and treat disease. An entire new standard of care is becoming a reality.

Lasers and pediatric dentistry are a perfect fit. There are a wide range of hard and soft dental procedures that may be accomplished using lasers. In fact, lasers are an alternative to conventional dental care on adults and, especially, children. Many of these procedures may be treatments dentists historically refer out to others. If you can understand and use your laser efficiently, you will discover that many of these are procedures that every dentist can easily complete.

The question that is often the major concern and barrier to introducing lasers in the office is how this investment will pay off, even more, recently described as return on investment (ROI). We prefer to speak of this as the secondary effect. If you can easily pay premiums on your investment, and the cost factor becomes a nonissue.

The purchasing of lasers is an investment, not an expense, for any dental practice.

Lasers represent a fundamental change in the entire way dentistry has been taught. We can now rethink and often rapidly G.V. Black’s principle of extension for prevention with the concept of minimally invasive microradentistry. We need to understand that laser dentistry is one portion of an entire new way of practicing conservative, pain-free dentistry.

The laser that we call the “all-purpose” laser is the Light-walker Er:YAG & Nd:YAG laser, manufactured by Fotona and distributed in the United States by Technology4Medicine. The Er:YAG produces its effect at 2940 nm and has as its primary tissue target water and hydroxyapatite. It is very safe, relatively, eliminates the smells and vibrations associated with the dental handpiece and, most importantly, is much more comfortable for the patient, significantly reducing the need for local anesthesia.

The use of the new generation erbium lasers for repair of incipient hard-tissue disease allows the dentist to provide a stress-free means of restoring teeth in a minimally invasive manner; most often with no shot and no numb lip, without the need for any local anesthetics.

The erbium laser can be used for restoring primary and permanent teeth, in eliminating or reducing the amount of local anesthetics. In most cases, the patient will not require numbing for Class I, 2 (sometimes), 5, 4, 5, 6 restorative procedures using bonded restorative materials. Using the concept of minimally invasive restorative procedures, the Er:YAG laser allows the operator to remove only diseased tissue and thus preserves much more of the healthy, unaffected tooth.

In cases where alloy is preferred, the laser’s anagelsia effect may also allow the dentist to create a restorative preparation using the erbium, which is a piece that is not meant for bonding.

The erbium laser is effective because of its effect on the target, water within the tooth structure. This effect occurs when the laser heats water within the target tissue, causing it to create small microscopic explosions (photothermal followed by photoacoustical effects). When applied to soft tissue, bone or teeth and cavities, the explosions then cause the areas to be vaporized.

Er:YAG laser 2940 nm: Soft-tissue procedures

There is a wide array of soft-tissue procedures that can be accomplished using the all-purpose laser: maxillary and mandibular frenum revisions, lingual frenum revisions, treatment of periocoroal pain or infection, removal of hyperplastic tissue by photoacoustical effects. When applied to soft tissue, bone or teeth and cavities, the explosions then cause the areas to be vaporized.

Pulpotomies

Parents often express concern about the need to take radiographs because of the nature of X-rays and their possible side effects on a child’s overall health. They question the use of alloys because of the chemical makeup of the alloys. Whether these should be a real concern in today’s dental care is open to debate, depending on your individual beliefs. There are also concerns by many, although not as loud, about the effect of various pulpotomy procedure mechanical devices used in pulpotomy procedures, such as fornomere.

Lasers provide a safe, nonchemical, effective and alternativa treatment for pulpotomies. During the span of eight years, post-treatment results on more than 4000 pulpotomies using the erbium laser show that this procedure provides ample evidence that this method is both effective and safe for children who were referred for introducing chemicals or using electrotherapy methods.

When the final result of orthodontic positioning of the front teeth results in gingival hyper trophy, the laser can be a useful tool to increase crown length and give the patient a more esthetic smile. This may often be accomplished without the need for local anesthesia. Patients who have medically induced hyperplastic tissue, such as patients requiring dilantin, can also have their tissue reduced and reshaped with the erbium.

In addition to the many examples described in this article, lasers can be used for additional procedures not usually required in pediatric dentistry, such as revisions of the abnormal maxillary frenum, often avoiding the need for soft-tissue grafts, crown-lengthening procedures where bone may require recontouring, apicoectomies, removal of hairy exostoses, removal of third molar impactions, removal of root remnants, incising and draining soft-tissue infections, advanced periodontal treatment, and the latest in advanced endodontic treatment via photoinduced photoacoustic streamlining.

Photoacoustic endodontics using PIPS: The goal of endodontic treatment is to obtain effective clean up and decontamination of the smear layer, bacteria and their byproducts in the root canal system. Clinically, traditional endodontic techniques use mechanical instruments, as well as ultrasonic and chemical irrigation, in an attempt to shape, clean and completely decontaminate the endodontic system but still fail short of successfully removing all of the infective microorganisms and debris. This is because of the complex root canal anatomy and the inability for common irrigants to penetrate into the lateral canals and the apical ramifications. It seems, therefore, appropriate to search for new materials, technologies and techniques that can improve the cleaning and the decontamination of these anatomical areas.

Among the new technologies, the laser has been studied in endodontics since the early 1970s1 and has become more widely used since the 90s.2 3 Different wavelengths have been shown to be effective in significantly reducing the bacteria in the infected canals, and important studies have confirmed these results in vitro.4 Studies reported that near infrared lasers are highly efficient in disinfecting the root canal surfaces and the dentinal walls (up to 750 microns for the diode 810 nm and up to 1 mm for the Nd:YAG 1064 nm). On the other hand, these wavelengths did not show effective results in debrid ing and cleaning the root canal surfaces and caused characteristic morphological alterations of the dentinal wall. The smear layer was only partially removed and the dentinal tubules primarily closed as a result of etching of the inorganic dentinal structures.5

Other studies reported the ability of the medium infrared laser in debulking and cleaning root canal walls.6 The bacterial load reduction after erbium laser irradiation demonstrated high on the dentin surfaces but low in depth of penetration because of the high absorption of laser energy on the dentin surface.7 Also the laser activation of commonly
more thermal damage as seen with other methodologies. The placement of the tip in the coronal portion of the treated tooth allows for a more minimally enlarged canal preparation with less thermal damage as seen with those techniques placed inside the canal system.

The root canal systems irrigated with 17 percent EDTA and laser activated for 20 seconds showed exposed collagen matrix, spread tubules, and the absence of smear layer and debris (Figs. 1-3). The rinsing with 5.25 percent sodium hypochlorite and laser irradiation for 20 seconds produced a strong activation of the solution, as reported by Mac-regor. Improving the disinfecting action of the sodium hypochlorite, the disintegrating action of PIPS is very effective both in the root surface, the lateral canals and the root dentinal tubules, as con-firmed with SEM and confocal studies (Fig. 4).

The profound and distant effect of PIPS eliminates the need to introduce the tip into the root canal system. Unlike traditional laser techniques requiring placement of the tip 1 mm from the accessory canal or even 5 mm of the apex as proposed for LAAI, the PIPS tip is placed in the coronal portion of the pulp chamber only and left stationary, allowing the photoacoustic effect to spread through the openings of each canal. A new tip design consisting of a 500-micron diameter, 12 mm long, tapered end is used for this technique (Fig. 5). The final 5 mm of coating is stripped from the tip to allow for greater lateral emission of energy compared to the frontal tip.

This mode of energy emission allows for improved lateral diffusion with low energy and enhanced photoacoustic effect.

Discussion
Laser irradiation is a common technique used in endodontics to improve the cleaning, the debridging and disinfection of the root canal system. Many wave-lengths and protocols are used. Near infrared lasers are used for the three-dimensional decon-}

used irrigants (LAI) resulted in statistically more effective removal of debris and smear layer in root canals compared with traditional techniques (CI) and ultrasound (PUI). Additionally, the laser activation method resulted in a strong modulating in reaction rate of NaOCl, significantly increasing production and consumption of available chlorine in comparison to ultra- sound activation.14,15

A recent study has reported how the use of an Er:YAG laser, equipped with a newly designed and stripped fiber, in combination with 17 percent EDTA solution, using very low pulse duration (0.1136 of a second) and low energy (20 mJ) resulted in effective debris and smear layer removal with minimal or no thermal damage to the organic dentinal structure through a photoacoustic technique called photon induced photoacoustic streaming or “PIPS.”14,15 Also the traditional irrigation protocol in combination with 5.25 percent sodium hypochlorite solution has been investigated and shown to reduce the bacterial load and its associated biofilm in the root canal system three dimensions.16

Other similar studies are in pro-}

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mena. The use of low energy (20 mJ) resulted in a three-dimen-}

sional positive effect.17 The laser thermal effect produced a strong activation of the water molecules of the irrigant solution, generating a strong acoustic wave that leads to the formation of an effective streaming of fluids inside the canal wall and also instrumented the dentinal tubules and the absence of smear layer and debris (Figs. 1-3). The rinsing with 5.25 percent sodium hypochlorite and laser irradiation for 20 seconds produced a strong activation of the solution, as reported by Mac-regor. Improving the disinfecting action of the sodium hypochlorite, the disintegrating action of PIPS is very effective both in the root surface, the lateral canals and the root dentinal tubules, as confirmed with SEM and confocal studies (Fig. 4).

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