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

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Introduction
Lasers provide an exciting new technology 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 laser physics, lasers are extremely safe and effective.

Using lasers for caries removal, periodontal treatment, endodontic treatment, bone management, cutting and shaping, and soft tissue procedures can reduce postoperative discomfort, infection and provide safe, simple in-office treatment. As a result, 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 US 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 of Yttrium-Aluminum-Garnet (Er:YAG) development 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 provide contactless treatment, the alveolar bone and soft tissue abnormalities and disease. An entire new standard of care is becoming a reality.

Lasers and paediatric dentistry are a perfect fit. There are a wide range of hard and soft dental procedures that may be completed using lasers as an alternative to conventional dental care on adults and, especially, children. Many of these procedures may be treatments dentists historically refer to other specialists; however, if you understand and use your laser efficiently, you will discover that many of these procedures that every dentist can easily complete.

The question that is often the major concern and barrier to investing in lasers is how this investment will pay for itself, more recently described as return on your investment (ROI). Will it pay for itself? We prefer to speak of this as the secondary effect. If you understand your laser, you will easily pay premiums on your investment, and the cost factor becomes a non-issue.

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 modify G.V. Black’s principle of extension for prevention with the concept of minimally invasive micro-endodontics. 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 LightWalker Er:YAG & Nd:YAG laser, manufactured by Fotona and distributed in the United States by Technology4Medicine. The Er:YAG produces its effect at 2,940 nm and has as its primary tissue target water and hydroxyapatite. It is very safe, relatively quiet, eliminates the smell and vibrations associated with the traditional handpiece, and most importantly, is much more comfortable for the patient, significantly reducing the need for local anaesthesia.

The use of the new generation erbium lasers for repair of incipient hard tissue diseases allows the dentist to provide a stress-free means of restoring teeth in a minimally invasive manner, most often without the need or pain necessary for any local anaesthetics.

The erbium laser can be used for restoring primary and permanent teeth, eliminating or reducing the amount of local anaesthetics. In most cases, the patient will not require anything for Class ‘I’ (some- times) and ‘II, III, IV, V’ 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, un-affected tooth.

In cases where alloy is preferred, the laser’s analgesia effect may also allow the dentist to create a restorative preparation using a conventional hand-piece that is not meant for bonding. The erbium laser is effective because of its effect on its target, water within the tooth structure. This effect occurs when the laser heats up water within the target tissue, causing it to create small microscopic explosions (photothermal followed by photoacoustic effects). When applied to soft tissue, bone or teeth and cavities, the explosions then cause the areas to be vaporized.

In addition to the many examples described in this article, lasers can be used for additional procedures not usually required in paediatric dentistry, such as revisions of the abnormal maxillary frenum, often avoiding the need for soft tissue grafts, crown-lengthening procedures where bone requires recontouring, apicectomies, removal of root remnants, incising and draining soft tissue infections, advanced periodontal treatments and the latest in advanced endodontic treatment via photoinduced photoacoustic streaming.

Photacoacoustic endodontics using PIPS
The goal of endodontic treatment is to obtain effective cleaning and the contamination 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 fall short of successfully removing all of the infective microorganisms and debris. This is because the complex root canal anatomy and the stability for common organisms to penetrate into the lateral canals and the apical ramifications. It seems, therefore, appropriate to search for new materials, techniques and technologies that can improve the cleaning and the decontamination of these anatomical areas.

Among the many technologies, the laser has been studied in endod-ontics since the early 1970s and has become more widely used since the '90s.

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. Studies reported that near infrared
laser are highly effective in disinfecting the root canal surfaces and the dentinal walls up to 750 microns through a single pulse at a very low energy (20 mJ) within the Nd:YAG (1064 nm). On the other hand, these wavelengths did not show effective results in debridging and cleansing the root canal surfaces and therefore organic morphological alterations of the dental wall. The smear layer was only partially removed and the dentin tubules primarily closed as a result of melting of the inorganic stratum.1

Other studies reported the ability of the medium infrared laser in debrid- ing and cleaning root canal walls.14,15 The bacterial load reduction after er- bium laser irradiation, demonstrat- ed high on the dentin surfaces, but low in depth of penetration because of the high absorption of laser en- ergy on the dentin surface.1 Also the laser activation of commercially used irrigants (LAI) resulted in statistically more effective removal of debris and smear layer in root canals compared with traditional techniques (C) and ultrasound (PIU).16,17 Additionally the laser activation method resulted in a strong modulation in reaction rate of the root canals through pro- ducing modification and consumption of available organic material in comparison to ultrasound activation.18

A recent study has reported how the use of an Er:YAG laser equipped with a newly designed radial and stripped tip was able to activate EDTA solution, using very low power pulse duration (50 microseconds) and low energy (50 mJ) to result in effec- tive debridges and smear layer removal within 30 seconds.18 This also confirmed the damage to the organic dentin structure through a photoacoustic canal cleaning effect (Fig. 3). The erbium laser (20 mJ, 200-500 microseconds) produces laser activated irrigation (PIPS)19 with excellent results, because of the high absorption of laser energy at 2940 nm, which is the peak absorption of water molecules of the irrigant solution that leads to the formation of an effec- tive stream of fluids inside the canal while eliminating the undesir- able thermal effects seen with other methodologies. The placement of the tip in the coronal portion only of the treated tooth allows for a more minimized enlarged canal prepara- tion with those techniques planned into the canal system. The root canal surfaces irritated with 17% EDTA and lasers for 20 seconds showed exposed collagen matrix, opened tubules and the absence of cavitation and debris (Figs. 3-9). The rinsing with 20% EDTA after laser irradiation and laser for 20 seconds produced a strong activation of the dentin, as confirmed by Macedo10,20 by improving the disfecting action of the sodium hypochlorite. The disfecting action of PIPS is even more effec- tive on the root surface, the lat- eral canals and the dental tubules, as confirmed by SEM and confocal (Fig. 4).

The profound and distant effect of PIPS eliminates the need to intro- duce any other disinfecting material into the root canal sys- tem. Unlike traditional laser tech- niques requiring placement of the tip 3 mm from the apex, or even 5 mm from the apex as proposed for LAP, the tip is placed in the cor- onal portion of the palatal chamber only and left stationary allowing the photoacoustic effect to spread into the openings of each canal. A new tip design resulted of a 400-micron diameter, 12 mm long, tapered end is used for this technique (Fig. 3). The- refore, the cutting is provided from the end to allow for greater lateral emission 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 tech- nique in endodontology to im- prove the root canal therapy while facilitating the search for the apical foramen, debridging and maintaining patency. As a result of the efficacy of PIPS the final size required for canal shaping can be significantly reduced, often to a size 32/44, allowing for a more minimally invasive and biomimetic preparation which can then be obtu- rated three dimensionally.

Conclusion

Lasers are an extremely versatile ad- dition to the dental practice and can be used in many instances instead of the conventional methods em- ployed by the vast majority of den- tal care practitioners. Laser endo-dontic practice should be viewed as an investment in the dental profession. When used with a good knowledge of laser physics, training and safety, lasers can help our patients a new standard of dental care.

References

The full list of references is available from the publisher.

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