Er:YAG & Nd:YAG dual wavelength laser From 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 ‘four 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.

Fluently 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 produce, discuss treatment plans and treat soft tissue abnormalities and disease. An entirely 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 new procedures may be treatments dentists historically refer to other specialists, however, if you understand how to 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 the 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 benefit. 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 prevention with the concept of minimally invasive micro-dentistry. We need to understand that laser dentistry is one portion of an entirely new way of practicing: conservative, pain-free dentistry.

The laser that we call the “all-purpose” laser is the Lightwalker Er:YAG laser, manufactured by Fotona and distributed in the United States by TechnologyMedicine. The Er:YAG produces its effect at 2,940 nm and has as its primary tissue target water and hydroxypatite. It is extremely safe, very quiet, 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 anaesthesia.

The use of the new generation erbium lasers for repair of incipient hard tissue defects 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 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 numbness for Class I, II, III, IV and V restorations using a device designed for laser-assisted cavitation.

The concept of minimal 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 ‘anesthesia’ 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 the 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 photomechanical effects). When applied to soft tissue, bone or teeth and cavities, the explosions then cause the areas to be vaporized.

Er:YAG laser 2,940 nm: Soft-tissue procedures

There is a wide array of soft-tissue procedures that are able to be completed using the all-purpose laser: maxillary and mandibular frenum revisions, lingual frenum revisions, treatment of periconical pain or infection, removal of hyperplastic tissue because of drugs or poor oral care in orthodontic patients, biopsies, treatment of aphthous ulcers and herpes labialis, palatal, removal of impacted teeth and in adults apicoectomies and bone re-contouring.

Pulpotomies

Patients often express concern about the need to take radiographs because of the nature of X-rays and their possible side effects on their child’s overall health. They question the use of alloys because of the chemical make-up of the alloy. 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 about the frequency of pulp therapy as a factor in caries, endodontic treatments and the latest in advanced endodontic treatment.
laser are highly efficient in disinfecting the root canal surfaces and the dentinal walls up to 790 microns through a strong modulation in reaction. They have been shown to produce cavitation phenomena, which can lead to thermal damage to the organic dentinal structure and cause characteristic morphological alterations of the dentinal walls. The smear layer is only partially removed and the dentinal tubules primarily closed as a result of the high absorption of laser energy on the dentin surface. Also the laser activation of coronal irrigants (LA) resulted in statistically more effective removal of debris and smear layer in root canals compared with traditional techniques (C) and ultrasonic (US) techniques (P<0.05). Additionally the laser activation method resulted in a strong modulation in reaction rate and high efficiency in production and consumption of available energy in comparison to ultrasonic activation. A recent study has reported how the use of an Er:YAG laser, equipped with a newly designed radial and striped tip, resulted in better results. A new four-step EDTA solution, using very low pulse duration (50 microseconds) and low energy (20 mJ) resulted in effective debris and smear layer removal with minimal thermal damage to the organic dentinal structure through a photoacoustic technique called photoacoustic ultrasound (PAUS). Cavitation and the absorption of laser energy into the fluid inside the root canals generates ultrasound that leads to the formation of an effective stream of fluids inside the canal while activating the underlying thermal effects seen with other methodologies. The placement of the tip in the intracanal portion only of the treated tooth allows for a more minimally enlarged canal preparation as seen with those techniques placed into the canal system. The root canal surfaces irritated with 17% EDTA and laser resulted in 20 seconds showed exposed collagen matrix, opened tubules and the absence of remnants and debris (Figs 3). The rinsing with sodium hypochlorite and laser irradiation for 20 seconds produced a strong activation of the reaction, as supported by Macdonald, improving the disinfecting action of the sodium hypochlorite.3 The disintegrating action of PIPS is very effective both on the root surface, the lateral canals and the dentinal tubules, as compared to SDM and conventional irrigation (Fig 4).

The profound and distant effect of PIPS eliminates the need to introduce another irrigant into the root canal system. Unlike traditional laser techniques, PIPS requires placement of the tip 1 mm from the apex, or even 5 mm from the apex as proposed for LAP, the PIPS tip is placed in the coronal third of the canal, only and left stationary allowing the photoacoustic effect to spread in the openings of each canal. A new tip design consisting of a 400-μm diameter, 12 mm long, tapered end is used for this technique (Fig 3). Thri- fold increase in cleaning and disinfecting activity of the fluids, PIPS, in particular, reduces all these risks and disadvan- tages, thanks to the position of the tip in the coronal orifice only, and to the use of minimally ablative energy levels of 20 mJ or less.

academic laser irradiation is a common tech- nique in endodontics to improve the cleaning and disinfection of the root canal system. Many wavelengths and pro- tocols are used. Near infrared lasers are used for the three-dimensional decontamination of the endodontic system. Near YAG and diode lasers use thermal energy to destroy bacteria. Observations reveal a certain grade of thermal injury to the root canal surface and create a typical morpho- logical damage. Moreover, they are not able to thoroughly remove the smear layer. On the contrary, erbium lasers are used for their effective smear layer reduction and the apical third is limited to the root surface. This is due to the size of the apex and its buckling movement during the activation process is related to the risk of apical perforation, ledge formation and surface thermal damage, because of the ablation ability of this wave- length. Moreover, the use of Nd:YAG lasers can be significantly reduced, often to a size 25/04, allowing for a more minimally invasive and biomimetic preparation which can then be obtu- rated three dimensionally.

Discussions

Lasers are an extremely versatile ad- 
dition to the dental practice and can be used in many instances of the conventional methods em- ployed by the vast majority of den- 
tists. However the clinical practice should be viewed as an investment in the learning of a new skill. The use of a good knowledge of laser physics, training and safety, lasers reduce our patients a new standard of 
dental care.

References


Conclusion

TIPs are used for the three-dimensional decontamination of the endodontic system. Many wavelengths and protocols are used. Near infrared lasers use thermal energy to destroy bacteria. Observations reveal a certain grade of thermal injury to the root canal surface and create a typical morphological damage. Moreover, they are not able to thoroughly remove the smear layer. On the contrary, erbium lasers are used for their effective smear layer reduction and the apical third is limited to the root surface. This is due to the size of the apex and its buckling movement during the activation process is related to the risk of apical perforation, ledge formation and surface thermal damage, because of the ablation ability of this wavelength. Moreover, the use of Nd:YAG lasers can be significantly reduced, often to a size 25/04, allowing for a more minimally invasive and biomimetic preparation which can then be obturated three dimensionally.

Scientific background

The macrophotographic recording of the LAI studies suggested that the effectiveness of PIPS in irrigant-filled root canals generated a streaming of bubbles at high speed through a cavitation and ultrasound (PUI). Additionally the laser activation method resulted in a strong modulation in reaction rate and high efficiency in production and consumption of available energy in comparison to ultrasonic activation.

Other similar studies are in progress for publication and the results are promising and suggest a three-di- mensional positive effect of this la- ser technique. The findings of our studies demonstrate that PIPS technique resulted in a safe and effective and decontaminating and disinfecting the root canal sys- tem. Our clinical trials showed that PIPS technique greatly simplifies root canal therapy while facilitating the search for the apex, 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 25/04, allowing for a more minimally invasive and biomimetic preparation which can then be obturated three dimensionally.

The purpose of this article is to pre- sent briefly the experimental back- ground of clinical laser techniques and to introduce the clinical protocol.

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