Er:YAG & Nd:YAG dual wavelength laser From every dentist to advanced photoacoustic endodontic applications (PIPs)

By Dr Lawrence Kotlow, Dr Enrico DiVito, USA, & Dr Giovanni Olivii, Italy

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’s (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 prepare, discuss treatment, make better decisions, and treat soft tissue abnormalities and disease. An entire new standard of care has become 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 methods” 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 are 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 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 prevention with the concept of minimally invasive micro-dentistry. We need to understand that laser dentistry is one portion of an entire new way of practice: 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 Technology4Medicine. The Er:YAG provides its effect at 2,940 nm and has as its primary tissue target water and hydroxypapatite. It is very safe, relatively 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 decay allows the dentist to provide a stress-free means of re-establishment of 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 numbing for Class I, II and III procedures. When used for cavity preparation, the erbium laser can improve the cleaning and the decontamination of these anatomical areas.

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 analgesia effect may also allow the dentist to create a restorative preparation using a conventional handpiece that is not meant for bonding. The erbium laser is effective because of its effect on 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.

Lasers provide a safe, non-chemical effective alternative treatment for pulpotomies. During eight years, post-treatment results on more than 4,000 pulpotomies using the erbium laser shows substantial evidence that this method is both effective and safe for children without the need for introducing chemicals or using electrolysis methods.

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

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 honeycombs, removal of third molar impactions, removal of root remnants, inising and draining soft tissue infections, advanced periodontal treatments and the latest in advanced endodontic treatment via photoinduced photoacoustic streaming.

Photacooustic 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 inability 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 anatomic areas.

Among the new technologies, the laser has been studied in endodontics since the early 1970s-73 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

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laser are highly efficient in disinfecting the root canal surfaces and the dentinal walls (up to 790 microns the distance that light can travel through a 5-mm Nd:YAG laser). On the other hand, these wavelengths did not show effective results in debridging and cleansing the root canal surfaces and cause irreversible morphological alterations of the dentinal wall. The smear layer was only partially removed and the dentin tubules primarily closed as a result of melting of the inorganic dentinal substances.

Other studies reported the ability of the medium infrared laser in debridging and cleaning root canal walls. 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. Also the laser activation of coronally irrigated roots (LAR) resulted in statistically more effective removal of debris and smear layer in root canals compared with traditional techniques (C) and ultrasonic irrigation (UI). Additionally, the laser activation method resulted in a strong modulation in reaction rate of the collagen matrix, opened tubules and the absorption of the fluids. To accomplish this streaming, PIPS, in particular, creates a strong “shock wave” pulse, absorbed by the water molecules, creating a strong pressure wave that leads to the formation of an effective streaming of fluids inside the canal while applying using the undesirable thermal effects seen with other methodologies. The placement of the tip in the proximal portion only of the treated tooth allows for a more maximally enclosed canal preparation seen with those techniques placed into the canal system. The root canal surfaces irrigated with 17 per cent EDTA and lasers for 20 seconds showed exposed collagen matrix, opened tubules and the absence of intracanal debris and fibrils. The X-ray imaging with the use of erbium lasers and laser irradiation for 20 seconds produced a strong activation of the collagen, and summarised by Macdonald, improving the disinfecting action of the sodium hypochlorite. The disinfecting action of PIPS is very effective both on the root surface, the lateral canals and the dentinal tubules, as confirmed by SEM and confocal studies (Fig. 4).

Trainive and profound illumination of PIPS eliminates the need to introduce the laser tip 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 portion of the canal with only and left stationary allowing the photoacoustic effect to spread into the openings of each canal. A new tip design consists of a 400-micron diameter, 12 mm long, tapered end is used for this technique (Fig. 3). The laser energy is applied through a small opening of the fiber tip in the end to allow for greater lateral emission energy compared to the front tip. This mode of energy emission allows for improved lateral diffusion with low energy and enhanced photoacoustic streaming or “PIPS.”

The erbium lasers are also used as a medium of activation of commonly used irrigants (LAI), avoiding the risk of thermal damage, while increasing the cleaning and disinfecting activity of the fluids. PIPS, in particular, reduces all these risks and disadvantages, 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.

The findings of our studies demonstrated that PIPS technique resulted in a safe and effective debridging and decontaminating the root canal system. 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.

Conclusion
Laser are an extremely versatile addition to the dental practice and can be used in many instances instead of the conventional methods employed by the vast majority of dentists. Incorporating a laser in the endodontic practice should be viewed as an important addition to the armamentarium. With a good knowledge of laser physics, training and safety, lasers can provide patients a new standard of dental care.

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The full list of references is available from the publisher.

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Dr Lawrence Kotlow, DDS, has been in private dental practice in Allentown, Pennsylvania since 1974. He is a board-certified pediatric dentist. He is a recognized and invited speaker at the Academy of Laser Dentistry.

Dr Enrico D’Avila, DDS, is an Adjunct Pro- fessor of the Arizona School of Dentistry and Oral Health. He is in private practice in Scottsdale, AZ, in conjunction with MORMOtherapy research group.

Dr Giovanni Orioli, MD, DDS is a Profes- sor of endodontics at the University of Genova School of Dentistry, where he is the director for the Laser in Dentistry Master Course with Prof. B. Benedictus. He is in private practice in Rome, Italy.

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