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

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Lasers provide a safe, non-chemical, effective and alternative treatment for 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 dental care, such as revisions of the abnormal mandibular frenum, often avoiding the need for soft tissue grafts, crown-lengthening procedures where bone requires recontouring, apicoectomies, removal of bony exostoses, removal of third molar impactions, removal of root remnants, incising and draining soft tissue infections, advanced periodontal treatments and the latest in advanced endodontic treatment via photon-induced photoacoustic streaming.

Photoacoustic endodontics using PIPS: The goal of endodontic treatment is to obtain effective cleaning 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 fall 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, techniques and technologies that can improve the cleaning and the decontamination of these anatomical areas.

Among the new technologies, the laser has been studied in endodontology since the early 1970s and has become more widely used since the 1980s. 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 efficient in disinfecting the root canal surfaces and the dentinal walls (up to 75 microms for the diode 810nm and up to 4mm for the Nd:YAG 1064 nm). On the other hand, these wavelengths did not show effective results in debridging 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 melting of the inorganic dentinal structures. 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 commonly used irrigants (PIPS) resulted in statistically more effective removal of debris and smear layer in root canals compared with traditional techniques (U) and ultrasound (PU). Additionally, the laser activation method resulted in a strong modulation in reaction rate.

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of NaOCl significantly increasing production and consumption of available chlorine in comparison to ultrasound activation.\(^9\)

A recent study has reported how the use of an E:YAG laser, equipped with a newly designed radial and stripped tip, in combination with 17 percent EDTA solution, ultrasonically delivered at 80 kHz ultrasound energy intensity, resulted in effective debris and smear layer removal with minimal or no thermal damage to the organic dentin structure through a photoacoustic technique called photon induced photoacoustic streaming or “IPS.”\(^1,8,9\) Also the same photoacoustic protocol in combination with 5.25 percent sodium hypochlorite has been investigated and shown to reduce the bacterial load and its associated biofilm in the root canal system three dimensionally.\(^6,9\) Other similar studies are in progress for publication and the results are promising and suggest a three-dimensional positive effect of this laseractivated decontamination (LAD) method.

**Scientific background**

The microphotographic recording of the LAI studies suggested that the erbium lasers used in irrigant-filled root canals generate a streaming of fluids at high speed through a cavitation effect.\(^1\) The laser thermal effect generates the expansion implosion of the water molecules of the irrigation solution, generating a secondary cavitation effect on the intracanal fluids. To accomplish this streaming, it is suggested the fiber be placed in the middle-third of the canal, 5 mm from the apex and stationary.\(^9\) This concept greatly simplifies the laser technique, without the need to reach the apex and to negotiate radicular curves.

Also, the recorded video of the new technique, PIPS, showed a strong agitation of the liquids inside the canals. It differs from the already cited LAD technique by activating the irrigant solutions in the root canal system through a profound photoacoustic and photo-mechanical phenomena. The use of low energy (50 microsec pulse, 20 mJ at 15 Hz, 0.5 W average power, or less) generates only a minimal thermal effect. The study with thermocouples applied to the radicular apical third revealed only 1.2 degrees C of thermal rise after 20 seconds and 1.5 degrees C after 40 seconds of continuous radiation.\(^1\)

When the erbium laser energy is delivered at only 50 microsecond pulse duration through a special designed tapered and stripped 400 microns tip (Fotona Light Walker, Technology4Medicines), it produces a large peak power of 440 watts when compared to a longer pulse duration. Each impulse, absorbed by the water molecules, creates a “shock wave” that leads to the formation of an effective streaming of fluids inside the canal while also limiting the undesirable thermal effects seen with other methodologies.

The placement of the tip in the coronal portion only of the treated tooth allows for a more minimally enlarged canal preparation with less thermal damage as seen with those techniques placed into the canal system.

The root canal surfaces irrigated with 17 percent EDTA and laser activated for 20 seconds showed exposed collagen matrix, opened tubules and the absence of smear layer and debris (Figs. 1-5). The running with 5.25 percent sodium hypochlorite and laser irradiation for 20 seconds produced a strong activation of the solution, as reported by McDonald,\(^1\) improving the disinfecting action of the sodium hypochlorite.\(^1\) The disinfecting action of IPS is very effective both on the root surface, the lateral canals and the dentinal tubules, as confirmed with SEM and confocal studies (Fig. 4).

The profound and distant effect of IPS 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 apex, or even 5 mm from the apex as proposed for LAD,\(^8\) the PIPS tip is placed in the coronal portion of the pulpal chamber only and left stationary, allowing the photoacoustic effect to spread into the endodontic system. A new tip design consisting of a 400 micron diameter, 12 mm long tapered end is used for this technique (Fig. 3). The final 5 mm of coating is stripped from the end 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 decontamination of the root canal system. Nd: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 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 removal while their bactericidal activity is limited to the root surface. The placing of the tip close to the apex and its back movement during the activation process is related to the risk of apical perforation, ledging and surface thermal damage, because of the ablation ability of this wave-length. Also, the combination of the near and medium infrared lasers has been proposed. A technique, called "twistline endodontic treatment (TET)," uses the erbium laser energy first, to clean the root canal surface and remove the smear layer, and the Neodimium:YAG laser second, used in dry mode as the final disinfecting step. All these techniques utilize traditional tips and fibers placed into the canal, close to the apex (1 mm) with all the corresponding thermal disadvantages observed in long, narrow and curve canals. 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 positioning 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 of the root canal system. Our clinical trials showed that PIPS technique greatly simplifies root canal therapy while facilitating the search for the apical terminus, debridging and maintaining patency.

As a result of the efficacy of PIPS, the final size required for canal shaping can be significantly reduced, in our case to a size 25/04, allowing for a more minimally invasive and biocompatible technique that can then be obturated three dimensionally.

**Conclusion**

Lasers 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 dental practice should be viewed as an investment rather than a cost. When used with a good knowledge of laser physics, training and safety, lasers provide our patients a new standard of dental care.

**References**


**Full list of references is available from the publisher.**

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**About the Author**

Lawrence Koflow, DDS, has been in private dental practice in Alhany, N.Y., since 1974. He is board certified in periodontics. He is a recognized standard periodontics course provider for the Academy of Laser Dentistry. Enrico DiNovo, DDS, is an adjunct professor at the Arizona School of Dentistry and Oral Health. He is in private practice at the Arizona Center for Laser Dentistry in Scottsdale, Ariz. in conjunction with National Dental Research Group. Giovanni Olivi, M.D., DDS, is a professor of endodontology at the University of Genoa School of Dentistry, where he is director for the Eicer in Dentistry Master Course with Prof. S. Benedetti. He is in private practice in Rome, Italy.