TwinLight™ laser-assisted endodontics

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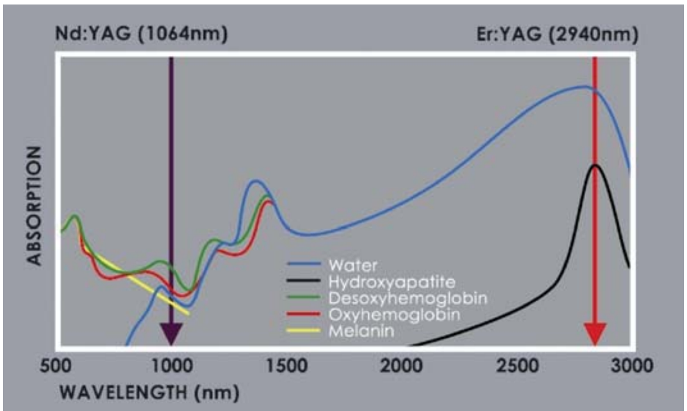

Fig. 1

Fig. 1_Absorption coefficient in human tissues, a as a function of laser wavelength. The absorption coefficient is at a minimum with the Nd:YAG laser wavelength (1,064 µm), and at the maximum with the Er:YAG laser wavelength (2,940 µm).
Fig. 2_Removal of the debris and smear layer from the root canal walls using the Er:YAG laser. The treatment is accompanied by collateral irrigation with saline solution.
Fig. 3_Deep decontamination with the Nd:YAG laser (3–5 times per session).

_Classical root treatment involves cleaning the root canal using mechanical means and rinsing with antibacterial solutions and solvents. However, there are two major disadvantages of standard chemo-mechanical preparations.[1] First, the bactericidal effect of the rinsing solutions is limited to the root canal. Because of the narrow diameter of the dentinal tubules and the high surface tension of the liquid solutions, they are able to penetrate only a small distance down the tubules. The penetration depth of chemical disinfectants reaches only 100 µm into the dentinal tubules[2], while the bacteria can penetrate over 1,000 µm from the canal lumen[3], and remain protected in the deeper layers of dentin. The second important disadvantage is that the mechanical preparation of side canals and other branches, as well as the complete removal of the smear layer, are impossible using classical means.


Fig. 2

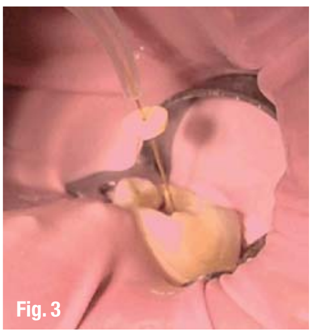
Fig. 3

Over the past twenty years many types of laser sources have been studied and used as a means to improve upon the classical dental treatments.[1, 4] No single "universal" laser source has been found that could be effectively and safely used for every dental procedure. Instead, as studies have demonstrated, each of the laser-assisted procedures should be performed with a laser that produces laser pulses at a wavelength that is known to be most effective for that particular procedure. In addition, many treatments would benefit immensely if they were performed with a succession or simultaneously using a multiplicity of laser sources. Of course, having a large number of laser sources in a practice would be impractical and very expensive. For this reason, the TwinLight™ treatment concept has been developed by Fotona d.d., based on the scientific understanding and clinical experience that for most laser-assisted treatments there exists an optimal combination of two basic complementary crystal laser sources, namely the Nd:YAG and the Er:YAG laser sources. The Nd:YAG laser wavelength (1,064 nm) is the most versatile and most deeply penetrating laser wavelength, while the Er:YAG laser wavelength (2,940 nm) is the wavelength with the highest absorption in human tissues (Fig. 1).

The use of the TwinLight™ laser-treatment concept in the field of endodontics was recently introduced by Dr Norbert Gutknecht.[5]

_The Nd:YAG laser wavelength in endodontics

For addressing the problem of deeply lying bacteria, lasers with a deep penetration into dentin, and preferably with a high peak-pulse power, are now being routinely used for disinfecting root canal systems.[6-15] As a result of their capability to spread and penetrate deeply into the dentinal walls, lasers have been demonstrated to be physically more efficient than traditional chemical irrigants in the decontamination of the dentinal walls.[13] The pulsed Nd:YAG laser has become the gold standard for this procedure.[1, 6–9] Of all dental laser wavelengths, the Nd:YAG laser wavelength has the deepest penetration in dentin, and the bactericidal effect of this laser has been demonstrated up to a depth of 1,000 µm.[7–9] The pulsed Nd:YAG (1,064 nm) laser results in a bacterial reduction of 85 % at 1,000 µm, while the continuous-wave diode lasers show a much lower disinfection effects (63 % at 750 µm for the 810 nm diode[14], and 33 % at 500 µm for the 980 nm diode.[15] Recent studies have shown that the higher effectiveness of the Nd:YAG laser in comparison to diode lasers can be attributed not only to the penetrating wavelength but also to the Nd:YAG laser's high peak-pulse power capability, which results in disinfecting temperature pulsing in the bacteria's immediate micro environment.[16]

_The Er:YAG laser wavelength in endodontics

In recent years, a laser solution has been proposed and developed that also addresses the second disadvantage of classically performed root canal treatments.[7–23] For the effective debridement and cleaning of the complex root canal system, the extremely high absorption of the pulsed Er:YAG laser wavelength (2,940 nm) in water and chemical irrigants is utilized to create a "cleansing" photo-acoustic effect within the root canal system.[5,21–24] Here, the erbium laser tip is placed into the tooth canal filled with either a saline solution or chemical irrigant. As the Er:YAG laser pulses are emitted from the fiber tip, they are immediately fully absorbed by the irrigant, creating shock waves within the irrigant that mechanically clean and debride the root canal system, even in otherwise difficult-to-reach side canals and branches. Since the action is purely mechanical, there is minimal thermal effect on the dentin. Canal walls treated photo-acoustically with the Er:YAG laser show a complete removal of the smear layer with open dentinal tubules and intact collagen structure.[23]

_TwinLight™ Endodontic Treatments

The latest TwinLight™ Endodontic Treatment (TET), as proposed by Dr Norbert Gutknecht of the University of Aachen[5], is based on the Fotona TwinLight™ complementary laser-wavelength treatment concept. The TET procedure successfully addresses the two disadvantages of classical root canal treatments since it combines both of the complementary "gold standard" wavelengths: the deeply penetrating Nd:YAG laser wavelength for the deep thermal disinfection of the dentin, and the highly absorbed Er:YAG

Fig. 4_Initial finding (10.12.2008) and follow-up (4.3.2009) after a TwinLight™ laser assisted endodontic treatment.

laser wavelength for the non-thermal, photo-acoustic cleaning and debridement of the complex root canal system.

In our practice, we use a dental laser system that incorporates both laser wavelengths, Nd:YAG and Er:YAG, in one device (the Fidelis AT, manufactured by Fotona d.d.). The TET procedure consists of the following three laser treatment steps.

In the first laser treatment step, the hard-tissue ablative capability of the Er:YAG laser is utilized to obtain free access to the pulp chamber. Compared to the classical procedure, this step allows a selective, pressure free and less painful opening of the irritated tissue. The bacterial load is not pushed into deeper root areas, and the danger of spreading of the bacterial wave throughout the body system is significantly reduced.

In the second laser treatment step, the root canal system is cleaned and debrided via the Er:YAG laser-induced photo-acoustics (Fig. 2). A saline solution and Preciso or Xpulse side-firing tips are used for this procedure (20–65 mJ, 15–25 Hz). Alternatively, the PIPS procedure[23] can be performed using EDTA @ 15–17 % solution and special radial, end stripped PIPS fiber tips (20 mJ, 10–50 Hz).

In the third laser-treatment step, the root canal is rinsed and dried, and then deeply decontaminated using the Nd:YAG laser (200 µm fiber, 1.5 W, 15 Hz) as is shown in Figure 3.

_Conclusion

A combination of laser treatments using two "gold standard" dental laser wavelengths can dramatically improve the prognosis of root-filled teeth. The integration of the Nd:YAG and Er:YAG laser wavelengths into a combined TwinLight™ procedure represents an endodontic therapy that successfully addresses both factors that complicate achieving sterility in the tooth: the anatomical root configuration and the characteristics of deeply resident bacterial flora. The TwinLight™ laser-assisted endodontic treatment starts with vibration-free removal of the hard tissue, to be continued by the selective removal of the smear layer and debris throughout the root-canal system, and finally followed by deep decontamination of the dentin tubules. The TwinLight™ approach represents a progressive decontamination from the first to the last step of the laser-assisted therapy. It reduces the risk of bacteria spreading into the perioperative area and the body system, which is particularly important for immuno-compromised patients. It also produces a clean three-dimensional root canal wall anatomy with open and decontaminated dentin tubules, which allows for a precise three-dimensional root filling. And lastly, the laser treatment may have a biomodulation effect on the immuno response as well as a biostimulation effect on the fibroblasts. A typical case is shown in Figure 4.

Besides root canal therapy, there are other excellent indications for the TwinLight™ treatment concept. In my practice we also apply the TwinLight™ concept (using the latest Er:YAG fiber tips, Preciso, and Xpulse) with laser-assisted implant setting in surgery, and to pin root canal management in temporaries or before cementation in prosthetic dentistry. Similarly, recent studies further suggest that the use of a combination of Nd:YAG and Er:YAG lasers in periodontal therapy, such as WPT (Wavelength-optimized Periodontal Therapy), can be associated with cementum-mediated new connective tissue attachment and apparent periodontal regeneration of diseased root surfaces.[25-26]

In conclusion, the combination of the two TwinLight™ complimentary laser wavelengths comes very close to being a truly "universal" dental laser system._

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