Laser-assisted dentistry in the daily office routine: A "multi-wave" concept

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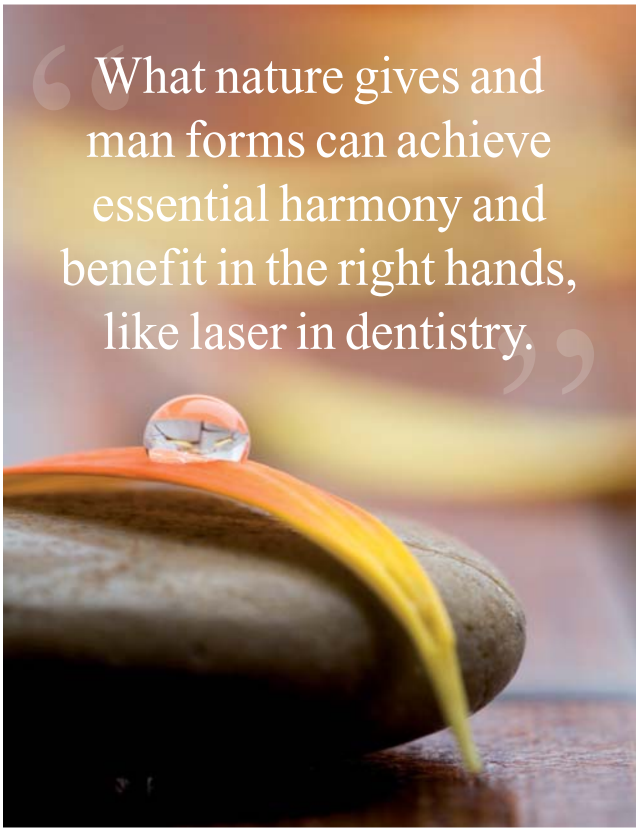


_Since Einstein pictured the nature of light and therefore postulated the basics of the concept of laser over almost a century ago, a long and sometimes rebellious time of experimentation elapsed before we finally witnessed a rapide and wide expansion of this instrument of light across all fields of dentistry in the new century.

At the beginning of the 1960s, Maiman developed the first laser, a ruby laser. Thus, a "solution looking for a problem" was born, then with no concrete indications. Only at the dawn of our millennium a vast range of wavelengths, pulse durations and power settings was achieved, to support safe and efficient clinical applications of lasers in dentistry today. Thus we have the privilege to be able to use the laser as an assistive or completely independent evidence-based tool in almost every field of dentistry, in terms of a multi-wave concept. In our office we classify laser-assisted dentistry into three categories, based on the focused main effect:

1. Ablation: mostly in aesthetic and operative dentistry and surgery;
2. Decontamination: mainly in endodontics, periodontology and surgery;
3. Photobiomodulation PBM as additional effect for the applications mentioned above, or as a therapy on its own, like essential bio-modulation or photodynamic therapy.

In this multi-wave concept, all three function together, unifying their basic features. We use following wavelengths in our office: 810 nm, 980 nm, 1,064 nm and 2,940 nm. This choice resulted gradually from increasing knowledge and need to expand the laser-assisted indications in our practice, based on the chart of laser-assisted dentistry by Prof Dr N. Gutknecht from the RWTH Aachen University. In dependency of the target tissue and the corresponding coefficient of absorption, we evaluate and select along the horizontal line the wavelength with the most efficient tissue interaction.

Our patients involved are given a folder of fact sheets, with a short description of any laser-assisted therapy and its benefits, which is accompanied by an individual consultation with our team on any scheduled laser therapy.

_About searching and finding

Any therapy is based on diagnostics and laser-assisted diagnostics is often a patient's first exposure to laser light at a first visit, a recall check-up or during an emergency consultation.

Laser-assisted detection tools for plaque, decay, calculus and concrements are based on the direct analysis of different qualities of fluorescence on the target (DIAGNOdent pen, KaVo; VisaProof, Dürr Dental; Figs. 1 & 2). Additional laser-based diagnostic tools for objective vitality tests are based on Laser Doppler Flowmetry or the intra-oral fluorescence visualisation for detection and prevention of early mucosal alteration through reduced fluorescence from the target tissue.

The DIAGNOdent pen, VistaProof and similar detection tools are based on the spectral analysis between the quality of light emission in the green/blue wavelength area of sound enamel/dentine and the red wavelength area infected by bacterial metabolic products. The numerical and/or visual result distinguishes between the necessity of therapy or just long therm monitoring of the detected spot.

_Ablation

Applications in conservative/operative dentistry

Since the new generation of Er:YAG lasers allows very subtle settings for pulse duration, frequency and energy, the array of indications covers almost every possible treatment of dental hard tissue from simple fissure sealing trough extended onlays, overlays, veneers to complex cases using CAD/CAM and CEREC. It is important to point out the positive and preventive side-effect of the resulting micropores after lasing, as being collecting tanks for fluoride, calcium and phosphate ions. This phenomenon optimises the enamel crystal structure, modifying carbon apatite versus hydroxyapatite and finally the stronger and essentially more resistent fluor-apatite. The removal of metal and porcelain fillings is still not an application of laser.

New pulse qualities, like the QSP (Fotona, Slovenija) allows us trough an additional sophisticated tuning of each single pulse, a very precise and even more efficient ablation with very specific structural changes in the tissue and on its surfaces and borders.

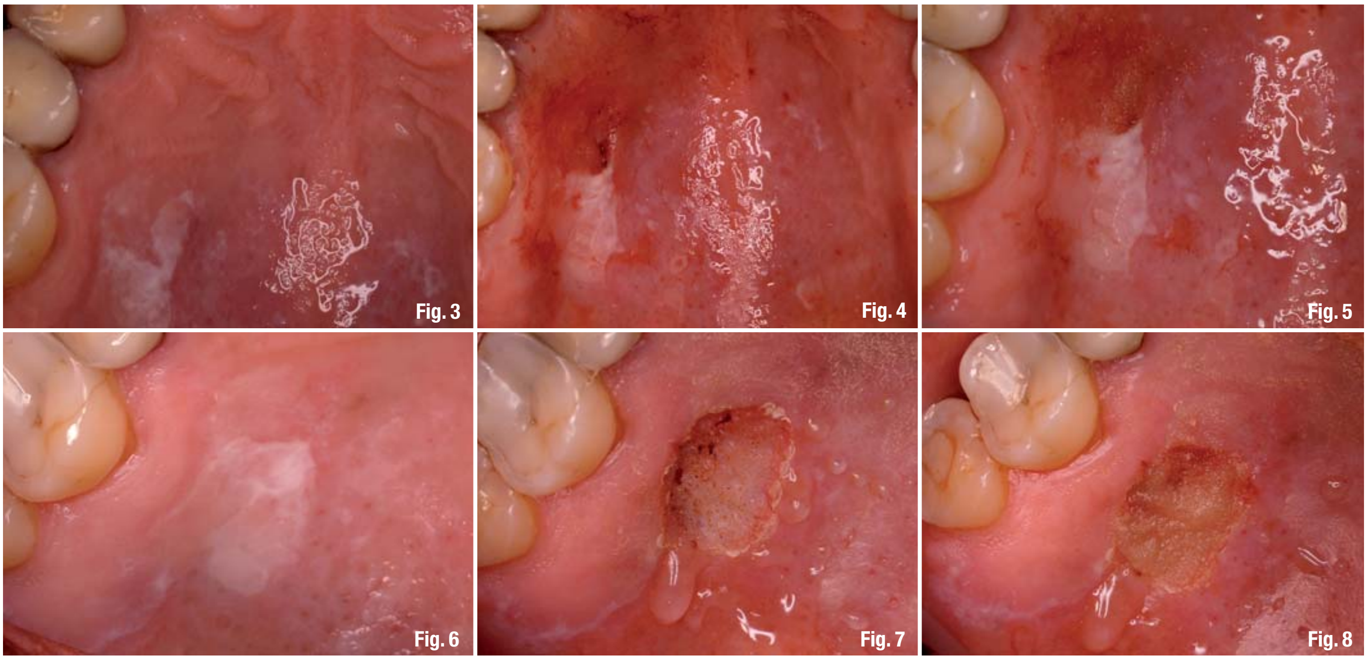
Laser-assisted aesthetic dentistry

This field includes tooth bleaching, management of hard and soft tissue and lasing dental hard tissue for CAD/CAM, different ceramic crowns and any kind of resins and porcelain veneers.

Our in-office power bleaching entails laser activation of a wavelength-specific activator, developed at the University of Vienna. The powder is mixed with 25 % H_2O_2 and applied to each buccal tooth surface. The ir-

Fig. 1_Detection of caries and concrements through spectral analysis and numerical differentiation between sound dental tissue, concrements and bacterial metabolic products with the DIAGNOdent pen.

Fig. 2_Imaging of plaque and caries through laser- and computer-assisted differentiation between sound enamel and contaminated dental hard tissue by bacterial by-products. In the photograph shown with the LED intra-oral camera is VistaProof.



Figs. 3–8_Partial ablation with the Er:YAG laser after earlier biopsy, removal of the second part after one week, subsequent monitoring after two to three weeks and at every recall. In the meantime, instructed self-monitoring by the patient.


Fig. 9


Fig. 10

Figs. 9 & 10_Buccal opening, root resection and surface modification of the peri-apical lesion on the lower left first molar with the Er:YAG laser, decontamination with the Nd:YAG laser and LLLT immediately post-op with the diode laser.

radiation time is 30 seconds, with up to three cycles per session. The redox reaction is primarily related to the specific activator and not to heat, and the presence of TiO_2 keeps the temperature rising in a medium range of 1 to 1.5 °C. No enamel surface alteration was shown on the SEM before or directly after the treatments with different wavelengths.

Modelling of soft gingival and hard bone tissue is often necessary to ensure the biological width and in aesthetic surgery as a first step to the right smile harmony.

Owing to the new settings, mostly of shorter or longer pulse durations, the erbium wavelength allows us to manage soft, hard and dental tissues with only one laser type and one handpiece.

Laser-assisted surgery

Oral surgery offers the widest range of indications for treatment by laser. The Er:YAG laser is the gold standard in our office for excellent handling of soft and hard tissue (Figs. 3–10), thanks to an efficient modulation of pulse duration, frequency, energy and water/air ratio.

Figs. 11–13_Step-by-step removal of the vascular lesion on the upper lip with the Nd:YAG laser using the ice cube technique: no invasive opening, but slow inner lasing of the lesion, initiated by non-contact Nd:YAG surface scanning through ice (five-minute weekly sessions).

The wavelengths of the 810 nm and 980 nm diode lasers extend the range to bio-modulation and a different laser approach to soft tissue modelling, decontamination and photodynamic therapy. The Nd:YAG laser completes the team as the wavelength for vascular lesions (Figs. 11–13), for deep decontamination, soft tissue surgery and as an alternative for the treatment of herpes and aphthae.

The Er:YAG laser is the laser of choice for a selective biological bone ablation and does not result in any classical thermal or mechanical trauma. The laser treatment results in a native, original and stress-free bone structure, allowing immediate revascularisation and initiating biological processes almost during surgery already and excellent tissue healing.

_Decontamination

Laser-assisted endodontics

Endodontics is certainly one of the most rewarding and best-investigated areas of laser-assisted evidence-based dentistry. The classic and highly efficient wavelengths of 810 nm and even stronger 1,064 nm enable a deep decontamination of the main root-canal system and the very important mosaic of lateral tubules and other anatomical variations, seen as obstacles to a successful traditional root-canal treatment or retreatment. The Nd:YAG laser decontaminates the complex anatomical root system also over the main canals, spreading its effect approximately 1.1 mm into the system, the distance of bacterial migration, allowing around 95 % of effectiveness. No other wavelength and no other rinsing of any nature can attain this phenomenon of decontamination.

Owing to the pigmentation of the involved bacteria (*Enterococcus faecalis* detected as the problem germ), the bactericidal effect focuses exactly on its target, with no collateral damage to the surrounding tissue, if settings are correct. The only resulting side-effect during lasing is the scattering to lower energy levels by means of bio-modulation of the neighbourhood tissue for faster cell regeneration and good wound healing.

Our in-office protocol includes usually two to three sessions of a combined Er:YAG/Nd:YAG laser use, known actually as Twinlight Endodontic Treatment.

Thanks to new erbium quartz fibres (Preciso tip, Fotona), which allow side-firing in any area of the root walls at different depths, we are able to remove smear layer and debris selectively in combination with saline solution, to perform an initial decontamination of


Fig. 11

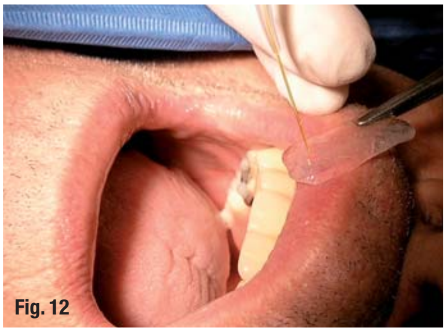
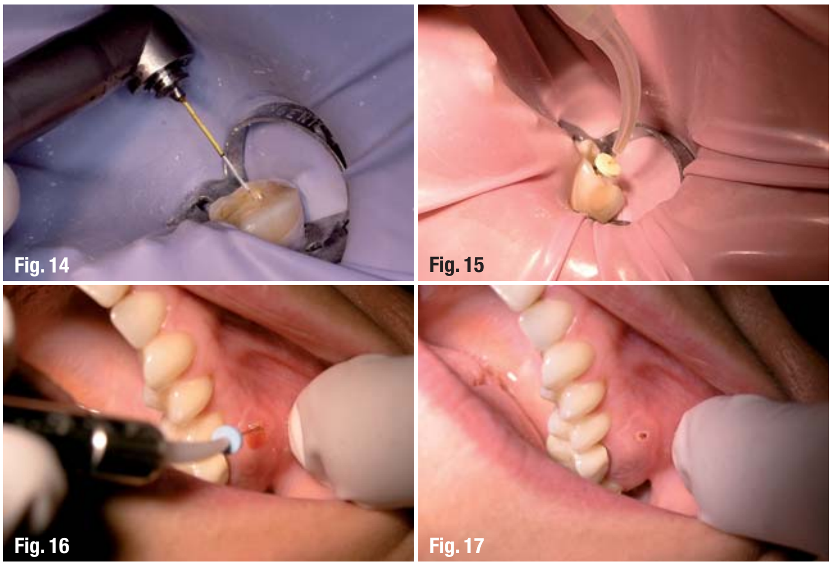


Fig. 12


Fig. 13

about 0.4 mm from the main canal into the lateral root system, to bio-stimulate (fibroblasts) and to leave an ideal microstructure on the walls for a 3-D filling.

The alternative erbium quartz fibre Pips (Photon Induced Photoacoustic Streaming by M.Colonna, E. DiVito and G. Olivi) System replaces even a part of the mechanical root canal treatment, in adjunct to all the effects already mentioned above. The Pips fibre (Fotona) is placed in the pulp chamber filled alternatively with 15 to 17 % EDTA and saline solution. It entails by laser activation the production of shockwaves in direction to each root canal separately, along the anatomy from cervical to apical at very low energy settings, converting thermal energy into an athermal mechanical precise and complete debridement (Fig. 14). Both protocols are completed in our office by a final deep decontamination laterally up to 1.1 mm with the Nd:YAG laser, perform-



Figs. 14 & 15_PIPS protocol, with the additional final dry and deep decontamination using the Nd:YAG laser.
Figs. 16 & 17_Laser-assisted treatment of the fistula to manage the symptoms and preserve the first upper left molar until the scheduled surgery, depending on patient's work schedule: rinsing, decontamination, de-epithelialisation and sloughing of the tunnel, followed by a bio-modulation with the 810 nm diode laser or Nd:YAG laser.

ing three to five cycles of constant circuiting movement at 2 mm/sec from apical to coronal, allowing an interval of 30 seconds of down-cooling between the actions (Fig. 15). An equivalent office protocol is followed to manage the prepared root canal before pin cementation, after a provisional time elapse. Besides the decontamination, it allows a stronger adhesive cementation, changing the root-canal anatomy by a precise 3-D superficial modification.

Fistulas are often a side-effect in active peri-apical or periodontal lesions. The decontamination of the bone lesion, the de-epithelialisation of the tunnel and the sloughing of the entrance are performed efficiently with a diode or Nd:YAG laser (Figs. 16 & 17). A scattered bio-modulation is always included.

Laser-assisted periodontology

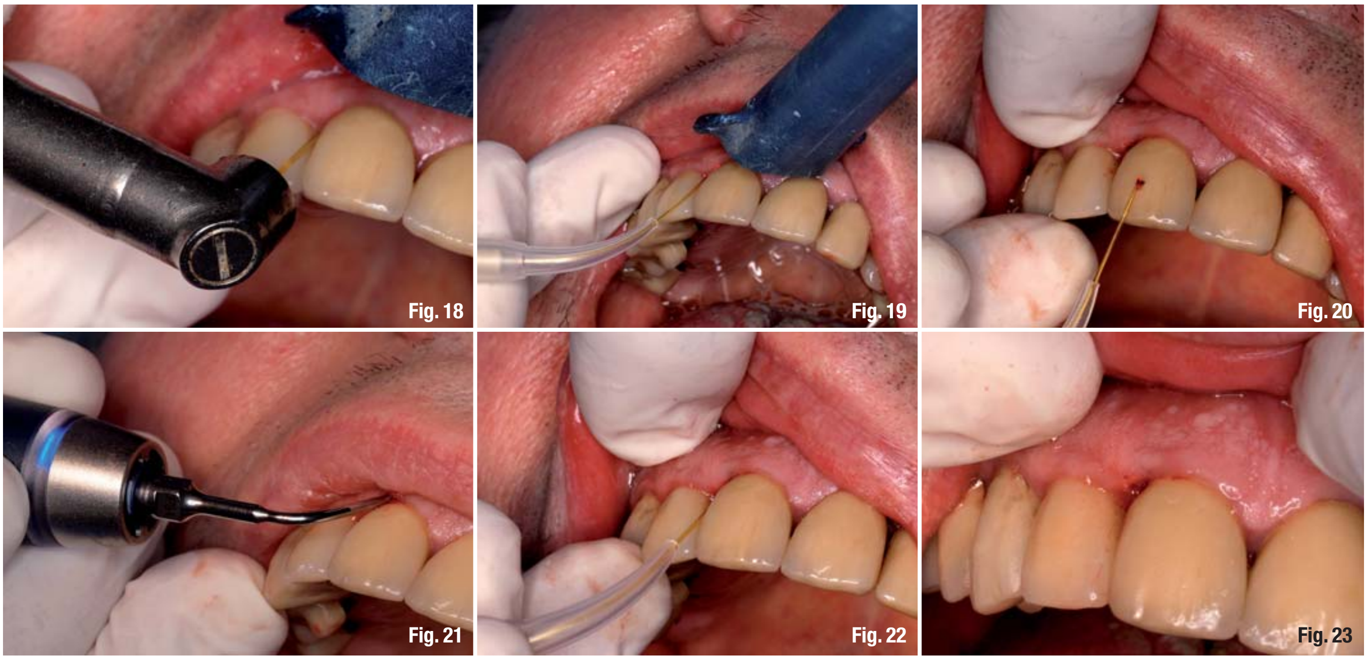
The bactericidal effect and the systematic removal of granulomatous soft and infected hard tissue during close debridement or open flap surgery, with a surface reactivation and bio-modulation of the remaining wound, are the pillars of modern periodontal therapy.

The corresponding laser assistance is highly efficient, as demonstrated with success during the last decade by various methods, such as LANAP. There are still some questions regarding the major benefits compared with the classic protocol, even if the combined use of laser-assisted and classic methods has been demonstrated as more advantageous and efficient by various studies. We set the perio chart in our office with the Florida probe, as an objective and hand-independent system, allowing direct comparisons of results in time and place.

During a closed periodontal treatment into pockets to a depth of 6 mm (or even more) the protocol suggests the assisting applications of Er:YAG, diode and/or Nd:YAG wavelengths. Periodontal open flap surgery is the primary action area of the Er:YAG laser, combined with a diode or an Nd:YAG laser for supplementary decontamination, bio-modulation and de-epithelialisation. The de-epithelialisation of the cervical tissue border and the upper buccal soft tissue area allows a discrete reattachment at the bottom of the pocket, before the faster re-epithelialisation of lesser quality from cervical starts growing down to the bottom. The laser-assisted perio protocol includes also peri-mucositis and/or peri-implantitis, often first with a closed debridement, as an emergency treatment to manage mainly the symptoms, and subsequently as open flap surgery to eliminate the cause.

Even if longer pulse durations are available, the closed decontamination of peri-implant areas with the Nd:YAG laser is still not included in our office protocol, because of its affinity to titanium and therefore more risky handling. In cases of closed decontamination, we switch to the 810 nm diode laser.

The regular office protocol is based on three steps (Figs. 18–23). Independent of the pocket anatomy, we start with an initial sterilisation with the diode, Nd:YAG or Er:YAG laser, to minimize the bacteria spreading into the body system. It is a medical sensible measure for all patients, but mandatory for the immune-compromised risk patients of any type. The second step entails classical closed debridement with ultrasound or piezo, supported by an Er:YAG-assisted concrement ablation on the hard root surface, and the elimination of granulomatous tissue on the soft gingival side, followed by a root surface modification and decontamination, to improve a local regeneration. The mandatory third step involves the final deep decontamination with the Nd:YAG laser in three to five cycles with a constant 2 mm/sec movement from apical to cervical along the soft tissue side of the pocket. The last cycle of more superficial



Figs. 18–23_Protocol for a laser-assisted closed perio debridement: initial superficial decontamination and ablation of granulomatous tissue with the Er:YAG laser and Varian 600 µm fibre (Fotona), supported by one cycle of the 810 nm diode laser or Nd:YAG laser. Chlorhexidine rinsing and debridement with concrement-detecting piezo (PerioScan, Sirona). Final deep decontamination and bio-modulation with the Nd:YAG and 810 nm diode lasers. A stable fibrin clot as biological wound dressing was achieved by longer Nd:YAG pulse durations.

movements at wider pulse durations entails the formation of a stable fibrin clot (Fig. 23), to close the cervical entrance by means of a biological wound dressing and in the de-epithelialisation versus buccal.

Photobiomodulation PBM or Laser Photo Therapy LPT

Photobiomodulation is one essential biological quality of laser-assisted therapy. Photobiomodulative radiations as a result of scattering are the positive side effect of a laser-assisted therapy. But they are also stand alone indications for LPT: the photodynamic therapy PDT (often part of the recall) and the specific photobiomodulation on cellular level. This one to optimise a high level wound healing in all kind of oral surgery, in cases of myoarthropathies, in laser acupuncture, local or systemic pain control, neuralgies, ghost pain, damage of specific neural areas and more. The new EmunDo PDT protocol (by Prof N. Gutknecht, University of Aachen, Germany), is the only one permitting the most efficient and complete decontamination of gram+ and gram- bacterias, allowing an immediate initialisation and activation trough a very low energetic level output of the diode 810 nm (by ARC).

Photobiomodulation enjoys finally its long deserved renaissance, rising up from the shade of uncertain anedoctical evidence to the sunny side of scientific evidence. The range of indications and the protocols are quite complex and mostly based on chemical effects in the cell or between cells, interactions, which need more space of discussion than the basic aim of this publication is. The motto is "similis simlibus curantur" or in another words "using the body natural resources to provide". Those phenomenons explain PBM acting as the third pillar of our multi-wave in-office concept.

_Conclusion

We have purposely not mentioned any concrete settings for the therapies and their protocols reviewed in this article. The aim was not to be instructive, but to give some inspiration for the daily office using laser-assisted dentistry. The parameters and settings, scientifically verified, are given by the manufacturers, to ensure safe use of the laser-assisted therapy. The essential requirements are basic knowledge about physics, physiology, wavelengths, their tissue interactions and their applications and the evidence-based background, and self confidence. The study of a range of evidence-based literature, including medical websites, and the participation at theoretical and practical CE courses and workshops are mandatory for a safe, conscious and productive laser use._

I would like to thank particularly my father Zlatko as one of the early pionieers of LLLT/PBM. He gave me the strength, a profound credo and the fundamental knowledge to understand the spirit of healing light and its unique biological benefits.

_contact laser

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