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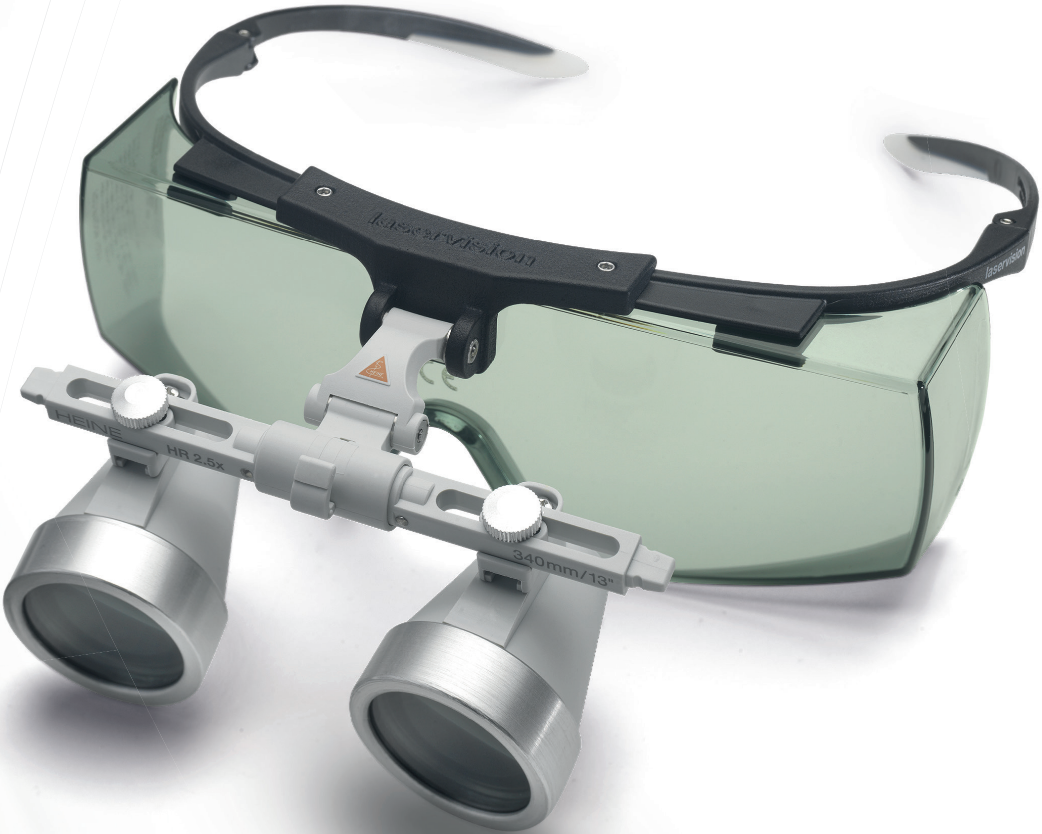

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oemus

Dr Youssef Sedky

Organising Chairman of the 18th ISLD World Congress

History carved with laser

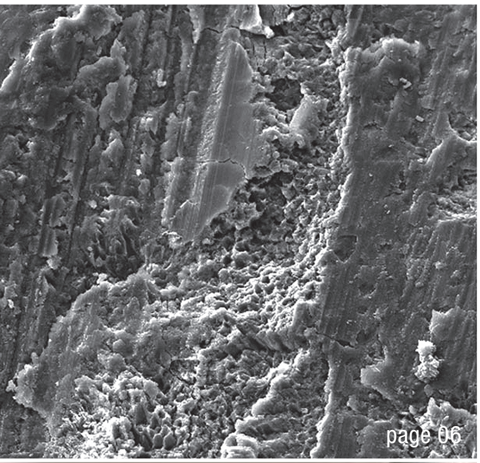
Dear friends and colleagues,

The applications of laser therapy in dentistry have added great value for our treatment modalities and results. Through the use of this state-of-the-art technology in our daily practice, we are among the few with access to this niche specialty. Looking back in history, it is evident that the benefits of light therapy had already been understood and applied thousands of years ago, by the Chinese, Greek and ancient Egyptian civilisations. The last did not only worship the sun, but they also understood the medical benefits of light therapy. The Ebers Papyrus (1550 bc), among the oldest medical papyri of ancient Egypt, shows how light therapy with sun rays can be applied for the treatment of skin lesions.

Modern science, technology and research have allowed us to expand the use of phototherapy through different modified-light sources, enabling dental practitioners to capitalise on the benefits of photo-biomodulation as a result. Photo-biomodulation as an adjunctive therapy has been thoroughly examined through research and proved to be of great value in orthodontics. Its effects include pain relief during orthodontic force application, acceleration of the rate of orthodontic tooth movement and an increase in the stabilisation of temporary anchorage devices.

From where we are today, we can look back on a great evolution of laser applications in dentistry. It is of utmost importance for us to keep ourselves continuously up to date on the latest research and the ongoing technological advancements made in laser dentistry. The board of the International Society for Laser Dentistry (ISLD) has also taken on this responsibility: after the great success of the congresses in Thessaloniki in 2017, in Aachen in 2018 and in Plovdiv in 2019, the board members and the general assembly have decided to take us on a journey to Egypt, a place of foundational knowledge and wisdom, by making Cairo the destination for the 18th ISLD World Congress, to be held from 1 to 3 October 2020.

Yours,
Dr Youssef Sedky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Effect of duration of Er,Cr:YSGG laser etching on dentine morphology

An *in vitro* study

Drs Farnaz Mahdisiar, Alireza Mirzaei, Alireza Fallah, Saeedeh Akhoundan, Iran &
Prof. Nobert Gutknecht, Germany

The conventional method of cavity preparation by rotary instruments is not favoured by many patients. On the other hand, dentine prepared as such is covered with smear layer, which is composed of dental hard tissue, carious debris, and residual bacteria. This decreases the dentine surface energy and prevents adequate adhesion to dentine.[1,2] Dentine is a major component of teeth. It is a complex substrate for bonding due to its heterogeneous composition, mainly organic structure, hydrophilic nature, and morphological variations. Introduction of adhesive primers with enhanced hydrophilicity for dentine surface conditioning and providing a stronger bond to more hydrophobic adhesive resins largely resolved this issue.[3–6] The conventional method of forming a strong bond to dentine is via phosphoric acid etching and removal of the mineral content to create microporosities within the collagen network. Upon removal of the hydroxyapatite crystals of the outer layer of dentine, about 50 % unfilled space and about 20 % of water remain in the dentine surface. In order to obtain a strong bond, resin should infiltrate into the collagen scaffold and form a hybrid layer. The primer also penetrates into the dentinal tubules concurrent with the formation of the hybrid layer. This results in formation of quite large resin tags. After etching, the tooth should be rinsed with air and water spray to thoroughly remove the acid and stop the etching process.[7–9] Otherwise, cysteine cathepsins, which can be activated in mildly acidic environments, may also activate matrix-bound matrix metalloproteinases and destabilise the hybrid layer in long term.[10,11] If the etching time is too long and the etched zone is too deep, decalcified dentine may not be fully impregnated. The etched but not impregnated space may serve as a mechanically weak zone.

After rinsing, drying of dentine must be performed cautiously. Even a short air blast from an air–water spray can inadvertently dehydrate the outer surface and cause the remaining collagen scaffold to collapse. Once it happens, the collagen mesh prevents the penetration of primer and bonding will fail. On the other hand, excess moisture tends to dilute the primer and interfere with resin penetration.[7–9] Excessive acid conditioning causes incomplete infiltration of resin monomers and creates a gap between resin tags and dental structure that decreases the bond strength by creating a weak zone.[12] In conventional surface treatment, the primer penetrates into the fluid-filled dentinal tubules. It is generally under-cured and forms soft flexible tags.[7,8] Today, laser system, as a novel modality, has been suggested for use as an alternative to dentine surface etching. Among laser systems, the erbium family of lasers is believed to be the most successful. There are several studies that have explored various parameters such as laser power and frequency for dentine etching and surface conditioning for proper bonding.[3–5] But no study has investigated the effects of duration of Er,Cr:YSGG laser etching on dentine surface morphology. The aim of this study was to evaluate ultrastructural morphological changes in dentine following different durations of Er,Cr:YSGG laser irradiation using scanning electron microscopy (SEM).

Duration of irradiation	T1	T2	T3	T4	T0 = control
Exposure 1	1	1	1	0	1
Exposure 2	1	1	1	0	1
Exposure 3	1	1	1	0	1
Exposure 4	1	1	1	0	1
Exposure 5	1	1	1	0	1

0 = smear layer was not observed
1 = smear layer was observed
T1–T4 = different durations of irradiation: T1, 5 s; T2, 10 s; T3, 20 s; T4, 40 s;
T0, no irradiation
Exposure 1–5 = number of irradiated areas by Er,Cr:YSGG laser

Table 1: Effect of duration of irradiation on the smear layer.

Materials and methods

Sample preparation

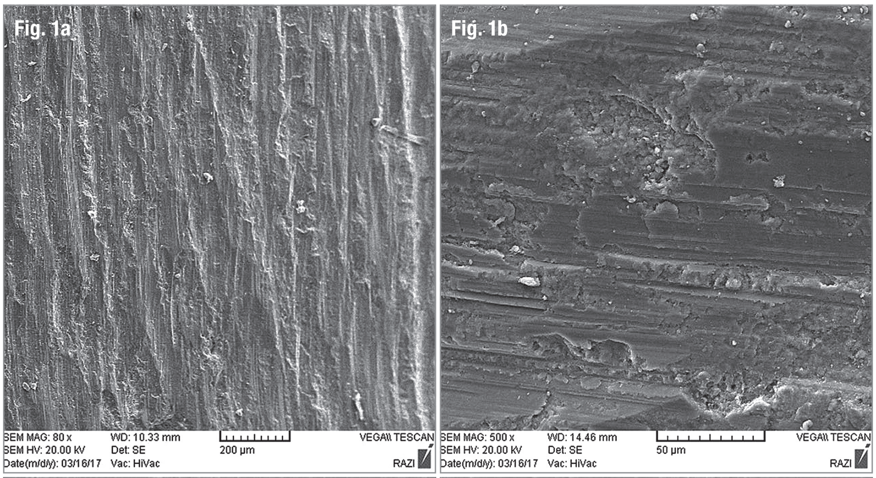
Twenty-five extracted human-impacted permanent third molars were used in this study. Soft tissue residues were completely removed from the tooth surfaces with a dental scaler. All teeth were then stored in distilled water containing 0.4% thymol for one week for disinfection. Then, samples were stored in distilled water at room temperature until the experiment. Each tooth was cut below the occlusal pit and fissure level, perpendicular to the longitudinal axis of the tooth by means of a high-speed handpiece and silicon carbide disc to remove the occlusal enamel and expose the superficial dentine surface. Next, an area measuring 5mm in length and 5mm in width was prepared on the occlusal surface of each tooth for laser irradiation.

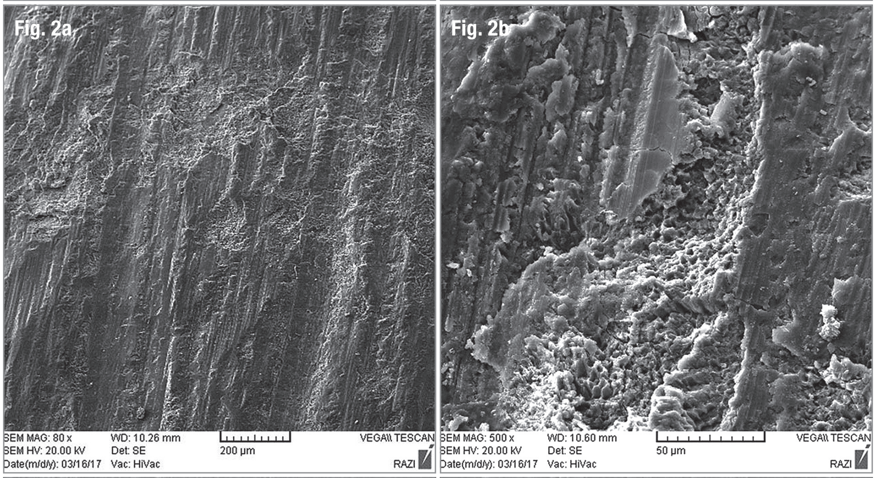
Laser application

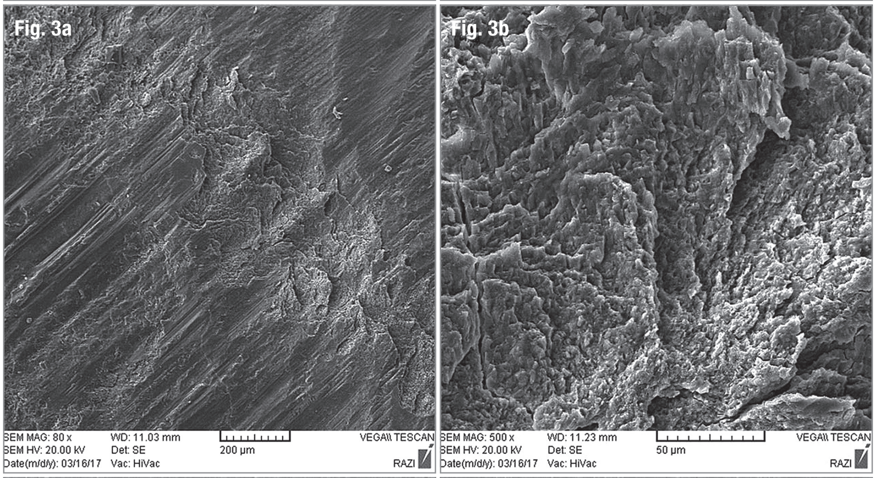
The marked occlusal area was irradiated with Er,Cr:YSGG laser (BIOLASE) at a wavelength of 2,780nm. The laser parameters were as follows: Output power 4.5W, peak power 1,500W, energy density per pulse 8.57J/cm^2, energy per pulse 0.09J, frequency 50Hz, water 80, air 60, pulse duration 60µs, tip diameter 600µm, cross section of tip 0.028cm^2, angle of radiation 8, irradiation surface 1.16mm, distance 2mm. The teeth were randomly divided into five groups according to the duration of laser irradiation: T1, 5s; T2, 10s; T3, 20s; T4, 40s; T0, no laser irradiation. After laser irradiation, the samples were stored in distilled water.

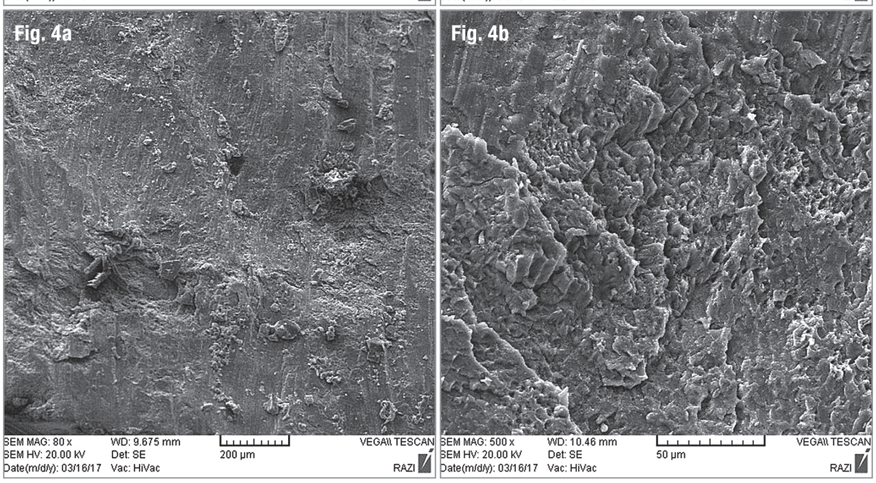
SEM analysis

The effects of laser irradiation on dentine surfaces were evaluated using SEM at 80x and 500x magnifications. Prior to SEM analysis, the samples were vacuum-dried and sputter-coated with gold for 180s. SEM observations were carried out at an accelerated voltage of 20kV with 25mm working distance. SEM findings were scored to evaluate the effect of duration of laser irradiation on the smear layer as follows: Score 0 = absence of smear layer; Score 1 = presence of smear layer. More SEM images were obtained from sample number 4 at 1.00kx, 3.00kx, 5.00kx, 10.00kx, and 20.00kx magnifications.

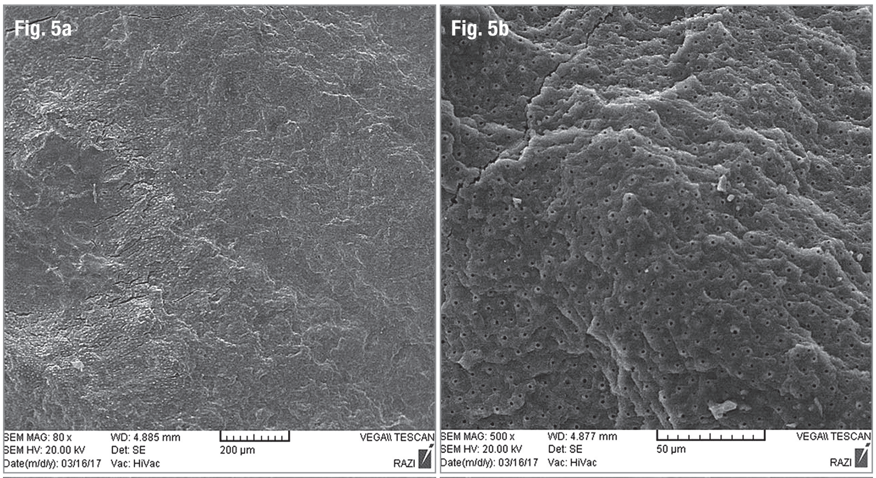


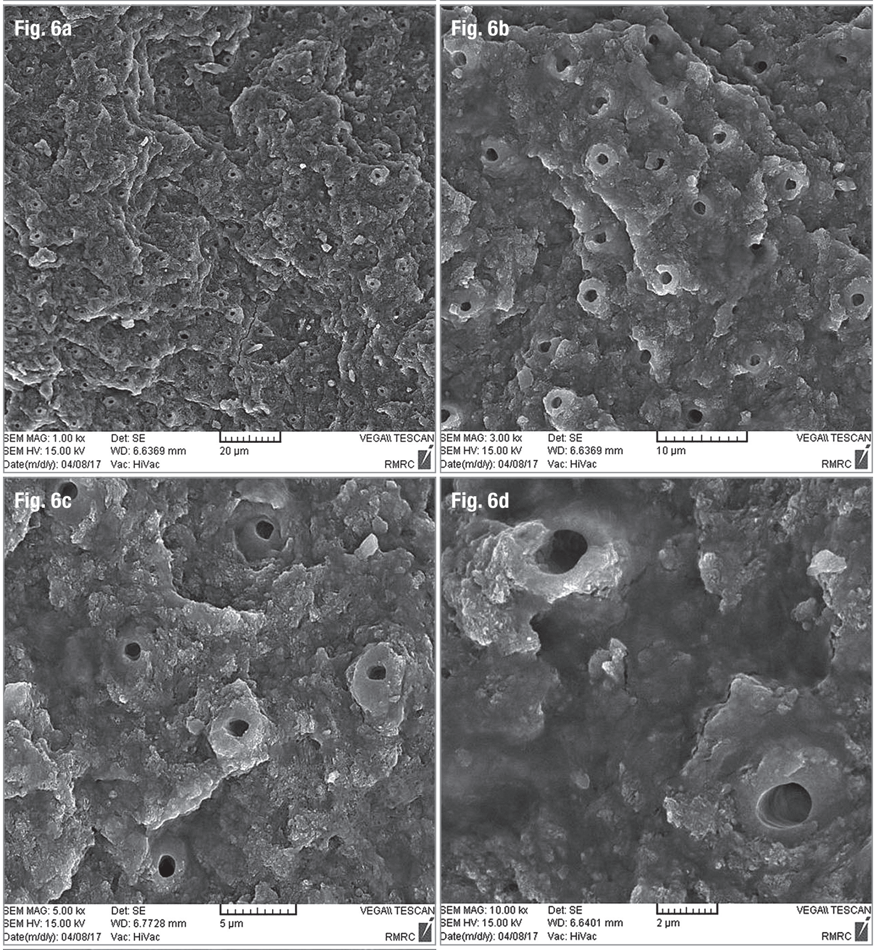


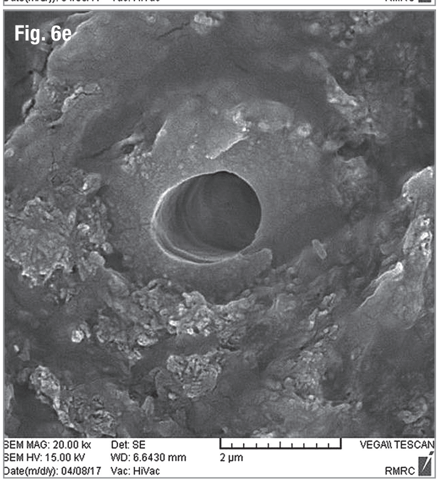




Figs. 1a & b: SEM micrographs of the dentine surfaces pre-treated only with silicon disc (control group). a 80x. b 500x. **Figs. 2a & b:** SEM micrographs of the dentine surfaces pre-treated with Er,Cr:YSGG laser irradiation for 5s. a 80x. b 500x. **Figs. 3a & b:** SEM micrographs of the dentine surfaces pre-treated with Er,Cr:YSGG laser irradiation for 10s. a 80x. b 500x. **Figs. 4a & b:** SEM micrographs of the dentine surfaces pre-treated with Er,Cr:YSGG laser irradiation for 20s. a 80x. b 500x.







Figs. 5a & b: SEM micrographs of the dentine surfaces pre-treated with Er,Cr:YSGG laser irradiation for 40 s. a 80x. b 500x. **Figs. 6a–e:** SEM micrographs of the dentine surfaces pre-treated with Er,Cr:YSGG laser irradiation for 40 s. a 1.00 kx. b 3.00 kx. c 5.00 kx. d 10.00 kx. e 20.00 kx.

Results

Analysis of the results with the Mann–Whitney U test showed that 40 s of irradiation in T4 group caused significant removal of the smear layer compared to T0 group ($P = 0.008$). Other durations of radiation did not completely remove the smear layer ($P = 1$, Table 1). SEM morphological analysis of the specimens showed different characteristics according to the surface pretreatment, as described below: Control group (T0): The surface was covered with smear layer (Fig. 1). Er,Cr:YSGG laser irradiation for 5, 10, and 20 s: The dentine surface in these groups revealed different amounts of the smear layer (Figs. 2–4). Er,Cr:YSGG laser irradiation for 40 s: Dentine surface in this group showed an irregular pattern without the smear layer, with open dentinal tubules and no enlargement. A prominent peritubular dentine appearance suggested greater removal of intertubular dentine due to its higher water sorption. There were no evident signs of melting or microcracks (Fig. 5). Among the different time durations of Er,Cr:YSGG laser irradiation, only 40 s of laser irradiation caused smear layer removal from the dentinal tubules. According to the results in group 4, further SEM analyses at 80 kx, 500 kx, 1.00 kx, 3.00 kx, 5.00 kx, 10.00 kx, and 20.00 kx magnifications were performed in this group (Fig. 6).

Discussion

The quality of the dentine-resin interface plays an important role in achieving a high quality and durable composite restoration.[13] Dentine preparation by rotary instruments creates smear layer on dentine surface that causes problems in obtaining suitable bond between the adhesives and dentine. On the other hand, the conventional method of smear layer removal includes the use of phosphoric acid on dentine for 15 s. This method has limitations such as (1) demineralisation that occurs with the removal of dentine mineral content, (2) over-etching since by increasing the duration of etching, greater depth of dentine is demineralised, (3) inadequate washing of the etchant results in unwanted continuation of the etching process, and (4) over-drying causes the collagen network to collapse and under-drying dilutes the primer. After the application of bonding agent, resin tags form by penetration of primer into the fluid-filled dentinal tubules. These resin tags are generally under-cured, soft, and flexible. In addition, the interface is prone to nano-leakage because of gap formation between tags and dentine due to incomplete penetration of adhesive.[3,7]

In the 1990s, erbium lasers were introduced for preparation of hard tissue as an alternative to rotary instruments. Er,Cr:YSGG laser (emitting at a wavelength of 2.79 μm) is an effective tool for removal of dental hard tissues.[14,15] This wavelength is absorbed by the hydroxyapatite and water. The hydroxyl radicals and water in hydroxyapatite crystals receive most of the laser energy. By water evaporation in the tooth mineral components, a large volumetric expansion occurs.[1,2] Next, micro-explosions occur that remove the hard tissue from the irradiated regions.[16] It has minimal side effects on the sound tooth structure.[1] Dentine conditioning with laser has advantages. As reported in some studies, the laser settings can be adjusted to physically etch the dentine surface. Power, frequency, and other parameters can be adjusted to prevent smear layer formation on the dentine surface. Laser does not cause dentine demineralisation. It does not have the risk of over-etching or over-/under-drying. The erbium laser-treated dentine is dehydrated prior to priming and bonding; thus, the resin tags are more likely to be long and strong.[1,17,18] Of studies on the effect of different laser parameters on dentine morphology, no study investigated the effect of various durations of Er,Cr:YSGG laser irradiation on dentine surface morphology. Dentine irradiated with Er,Cr:YSGG laser shows a microscopically rough surface without demineralisation,[19,20] open dentinal tubules,[21–23] no smear layer, and satisfactory sterilisation of the cavity.[24] These characteristics are considered as an advantage of laser preparation if composite resins are to be applied as the filling materials.[25]

The Er,Cr:YSGG laser setting used in this study included 4.5 W average power, 1,500 W peak power, 0.09 J energy per pulse, 50 Hz frequency, 8.57 J/cm^2 energy density, 80 % water and 60 % air, pulse duration of 60 μs, and distance of 2 mm above the surface. The energy density used in our study was not within the ablation range. Only dentine surface was etched and conditioned for the bonding process. Five, 10, and 20 s of laser irradiation caused different amounts of smear layer. The applied Er,Cr:YSGG laser setting with 40 s of duration caused a scaly-like appearance on the surface with less homogenous and less regular surface creating a micro-retentive pattern on dentine without heat injury or melting, which is favourable for bonding process. The dentine surface showed no smear layer; dentinal tubules were open; and the subsurface was not demineralised. Open tubules and absence of smear layer are additional factors that enhance bonding to laser-treated dentine.[14] This can be explained by micro-explosions at the tissue surface, resulting from the sudden boiling of water within the tissue (thermomechanical ablation).[26] The results obtained from this study can be used in further studies to evaluate the composite bond strength with different bonding systems.

Conclusion

Forty seconds of laser irradiation with the aforementioned parameters eliminated the smear layer from the dentine surface, and the obtained surface had microretentive pattern on dentine and open tubules without heat injury or melting and demineralisation which was suitable morphology for bond to composite resin. Laser irradiation for less than 40 s could not completely remove the smear layer from the surface. Each one of these surfaces could have optimum bonding with composite by applying different adhesives systems which should be investigated in further studies.

Editorial note: This article was originally published by Springer International in Lasers in Dental Science *(Mahdisiar, F., Mirzaei, A., Fallah, A. et al. Laser Dent Sci [2018] 2:213. https://doi.org/10.1007/s41547-018-0038-z). It is reprinted here (with editing changes) with permission. Also, the authors declare that they have no conflict of interest. In addition, this article does not contain any studies with human participants or animals performed by any of the authors. This article was done on extracted human third molars, and it does not include any human participant. For this type of study, formal consent is not required.*

Literature

about the author

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The treatment approach to caries using the Er:YAG laser

Prof. Roly Kornblit, Italy

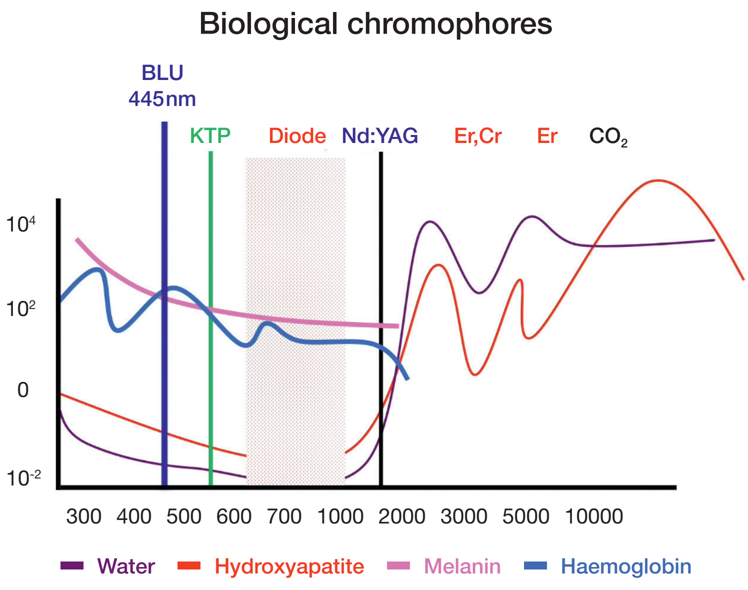


Fig. 1: The absorption of the 2,940 nm wavelength by water and hydroxyapatite.

Introduction

Dental caries, a disease process with a multifactorial aetiology in which bacteria assume an important role, is still the most common pathology in dentistry. The traditional approach of restorative dentistry usually has been to remove the decayed tissue using mechanical or manual instruments and to restore the residual tooth substance with various materials according to functional requirements. A modern, alternative approach to management of caries can instead aim not only at eliminating the decay but also at treating the infection.

Dental caries

In modern dentistry, caries is managed as an infectious disease in which the lesion is divided in two layers. The first, the infected layer, is heavily contaminated by bacteria and is composed of soft amorphic dentine (denatured collagen matrix) with no potential ability to remineralise. The second, the affected underlying layer, is less contaminated by bacteria and is partially demineralised with an intact collagen matrix, retaining the potential to remineralise.

Caries treatment

The objective of a minimally invasive dentistry (MID) approach to caries removal is to stop the disease process and to restore lost tooth structure and function, maximising the health potential of the tooth. One of the most important concepts of MID is to preserve as much of the dental tissue as possible. The advancements made in adhesive dental materials help to preserve the tooth

Fig. 2: Different tip diameters that delimit different-sized ablation areas (0.2–1.3 mm).

structure, since adhesive materials do not require any incorporation of mechanical retention features. MID adopts a philosophy that integrates prevention, remineralisation and minimal intervention for the placement and replacement of restorations. MID reaches the treatment objective using the least invasive surgical approach with removal of the minimal amount of healthy tissue. Conserving hard dental tissue increases the longevity of the restored tooth. In the context of paediatric dentistry, conserving the tooth structure is even more important, because the crowns of the primary teeth are smaller than those of the permanent teeth, which, once erupted, have a large pulp chamber during childhood.

The Er:YAG laser

The wavelength of an Er:YAG laser of 2,940 nm coincides with the absorption peak of water (Fig. 1). The Er:YAG laser is adapted for dental hard tissue ablation, since the main chromophores for 2,940 nm wavelength absorption are water and hydroxyapatite. Maximum absorption in water results in an effective micro-explosion mechanism. In today's dentistry, the Er:YAG laser is mainly used for the ablation of hard tissue (enamel, dentine and bone), but it can also be used for the treatment of soft tissue. Many academic papers have reported that Er:YAG laser ablation of enamel and dentine is effective and efficient and produces no heat damage to the pulp or carbonisation or cracks of the irradiated enamel and dentinal surface. Moreover, the biostimulation effect, the selective tissue ablation and the low penetration depth are among the Er:YAG laser properties that guarantee optimal results of hard-tissue high-technology Er:YAG treatments.

Caries treatment with the Er:YAG laser

The Er:YAG laser may be an alternative therapeutic modality for treating dental caries. The explosive vaporisation creates a plume of ablation of the carious tissue. Also, the ablative action is due to a combination of photothermal and photomechanical effects caused by the micro-explosions of water on the target tissue. The caries is ablated under water cooling using tap water and with high-speed suction to manage the plume of the carious tissue.

Caries treatment with Er:YAG laser fulfils many of the requirements of MID: the ability to ablate small areas of the infected layer guarantees maximum conservation of the tooth structure; the diameter of the Er:YAG laser in contact mode delimits an ablation area of 0.8–1.3 mm in diameter (in fact the ablation area may be even smaller; Fig. 2) so that irradiating dental hard tissue with laser allows ablation of areas no larger than 0.8 mm in diameter (Fig. 3). When using the Er:YAG laser, there is good visual control of the ablation area, offering the possibility of vaporising such small areas (Fig. 4). Thus, it is easier to vaporise only infected tissue and to stop the moment the affected zone has been reached. In this way, in accordance with MID, we can conserve the affected but repairable tissue. Moreover, as the amorphic dentine infected layer is richer in water, as a result of the enzymatic proteolysis of the collagen matrix, laser ablation of the infected layer is quicker compared with ablation of the affected layer or healthy dentine. Using the antibacterial property of the Er:YAG laser, it is possible to decontaminate the affected layer, which retains its remineralisation potential.

The bactericidal effect of the laser system on the dentinal surface has been demonstrated by many authors and in numerous studies. Various microbiological studies have tested the bactericidal ability of different laser systems. These studies confirm that the Er:YAG laser is a suitable system for the disinfection of the dentinal surface in cavity preparation, compared with conventional methods, with which it is difficult to eliminate infection from dentine even after removing all the carious tissue. Other studies have reported the absence of bacteria to a dentinal depth of 1 mm after laser irradiation. The good disinfection of the contaminated dentine prevents failure of the restorative process (secondary caries). Decontaminating the affected layer after removing the soft amorphic dentine

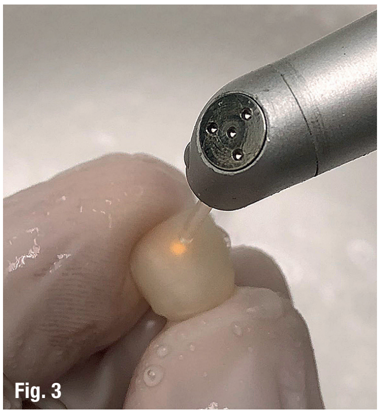


Fig. 3

Fig. 4

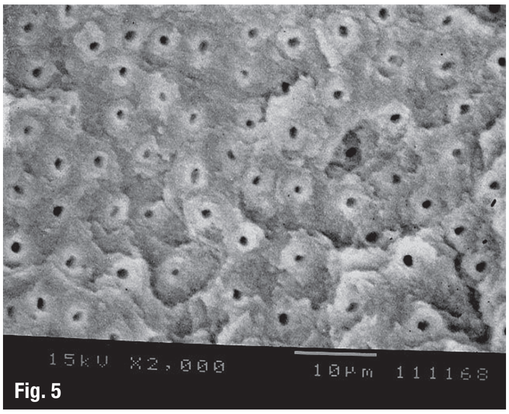


Fig. 5

Fig. 3: Irradiating dental hard tissue with a laser tip of 1.3 mm allows ablation of areas no larger than 1.3 mm. **Fig. 4:** Good visual control of the ablation procedure contact-free. **Fig. 5:** The dentinal surface under SEM after Er:YAG laser irradiation: surface without a smear layer and with open dentinal tubules.

(which is richer in water and thus easier to remove by laser than the healthy dentine) can help prevent possible future pulp complications.

Restoration of the tooth after Er:YAG laser caries removal

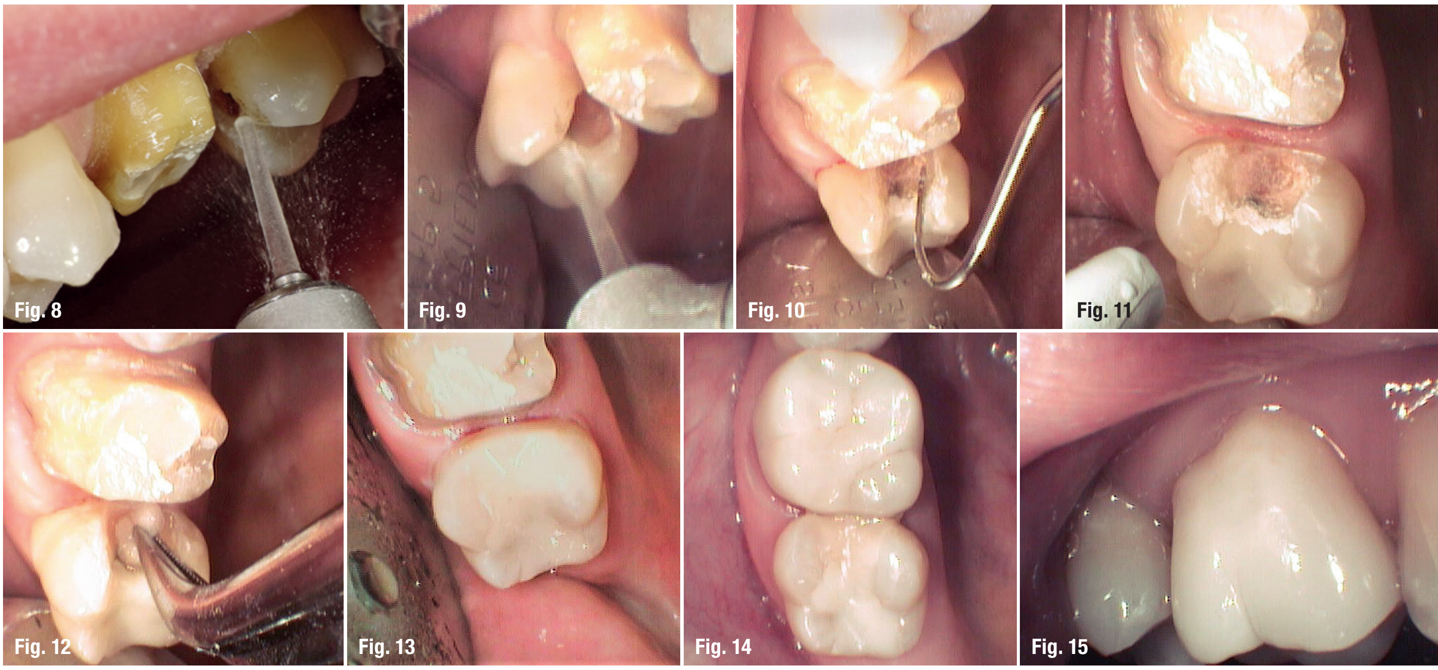
The introduction of resin-based composite restorative materials in dentistry aided the pursuit of the goals of MID. Conditioning the dentinal surface removes the smear layer and opens the dentinal tubules after bur preparation, forming a defined hybrid layer and resin tags of the composite material in the opened tubules. In contrast to bur preparation, the ablation of hard dental tissue with the Er:YAG laser leaves a dentinal surface without a smear layer (Fig. 5). The lack of smear layer allows the formation of a resin tag hybrid layer in the opened dentinal tubules, resulting in a better retention of the adhesive composite as a result. Some studies have also shown an enlargement of the dentinal tubules after Er:YAG laser irradiation. As for the hybrid layer, a result of penetration of the composite monomer within the collagen fibres exposed at a depth of 3–10 µ, several studies have shown that this bond is lower in a cavity prepared with an erbium laser than with rotary instruments. This was demonstrated to be due to alteration of the collagen fibres caused by thermal damage by the laser ablation.

The denaturation of collagen fibres, causing loss of their cross-linked basis, results in fibre fusing and the disappearance of the interfibrillar spaces. Thus, the monomer of the adhesive material is not able to penetrate into the interfibrillar spaces to form the hybrid layer. By etching the laser-treated dentinal surface or applying a 5 % sodium hypochlorite (NaOCl) solution for 30 seconds prior to the application of the composite monomer, it is possible to remove the thermally denatured collagen fibres without affecting the mechanical properties of the dentine, leaving the inorganic component intact. It is important to note that a better adhesion to the dentinal surface is even more important in primary teeth, where there is a smaller amount of dental tissue. In using an adhesive system after laser preparation of the tooth, preparation of the enamel surface by laser should be followed by acid etching. This allows regularisation of the enamel prisms and increases their wetting ability, the penetration strength and the bonding of the adhesive material, for less microleakage at the enamel–composite interface.

Fig. 6

Fig. 7

Clinical case—Fig. 6: Carious tissue on the mesial surface of the maxillary second molar. **Fig. 7:** Beginning of the removal of the caries using a very short tip of 1.3 mm in diameter at a distance of about 10 mm from the tooth surface in a non-contact mode.



Clinical case—Figs. 8 & 9: Removal of the caries-infected tissue using a tip of 14.0 mm in length and 1.3 mm in diameter by inserting the tip inside the cavity at a distance of about 2 mm from the carious tissue. **Fig. 10:** Checking progress of removal of the amorphic dentine infected layer with a dental explorer (probe). **Fig. 11:** The cavity after removal of the infected layer and decontamination of the affected layer with the Er:YAG laser. **Fig. 12:** Removal of the thermally denatured collagen fibres of the irradiated dentine using a cotton pellet soaked in 5% NaOCl. **Fig. 13:** The tooth restored with composite material. **Figs. 14 & 15:** Situation at follow-up 12 months after treatment, occlusal and vestibular view.

Deep caries treatment—a case example

A 49-year-old female patient presented who was in good general health. During the replacement of a crown on the maxillary first molar for aesthetic reasons, carious tissue on the mesial surface of the maxillary second molar was detected (Fig. 6). The caries was removed with an Er:YAG laser (LiteTouch, Light Instruments). The removal began by using a very short tip of 4.0 mm in length (magnum) and 1.3 mm in diameter at a distance of 10 mm from the tooth surface in a non-contact mode with energy of 300 mJ and 20 Hz, orientating the laser beam between the two molars against the mesial caries surface (Fig. 7). Then, progressing deeper into the caries-infected cavity, for a more precise ablation, the tip was replaced with a longer one of 14.0 mm in length and 1.3 mm in diameter, inserting the extremity of the tip inside the cavity at a distance of about 2 mm from the carious tissue, continuing until all the infected layer had been removed (Figs. 8 & 9). The ablation of the caries-infected tissue was done in a minimally invasive mode, layer by layer, covering small areas of 1.3 mm in diameter, ablating just the infected tissue, trying not to expose the pulp chamber and stopping from time to time to check progress of removal of the infected layer with the dental explorer (Figs. 10 & 11). The disinfection of the remaining affected layer was obtained by laser irradiation. The tooth was restored with composite material, after placing a small cotton pellet soaked in 5 % NaOCl on the dentinal surface for 30 seconds, and an etch and rinse adhesive material (fourth generation; Figs. 12 & 13). The vitality of the restored tooth was checked and confirmed after 12 months (Figs. 14 & 15).

about the author

Prof. Roly Kornblit is an Italy-based dentist specialised in dental lasers. He is the Coordinator of Laser Treatments at the Pediatric Dentistry Department, Goldschleger School of Dental Medicine, Tel Aviv University and a lecturer of Laser in Dentistry at the Hebrew University, Hadassah Medical School, Jerusalem (Israel). He was previously the scientific coordinator of the Master's Program at the Sapienza University of Rome in Italy. Prof. Kornblit is a frequently invited speaker at dental conferences and laser congresses around the globe and is an internationally published author.

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Severe peri-implantitis treated with the Er,Cr:YSGG laser

Dr Theodoros Tachmatzidis, Dr Dimitris Strakas, Dr Nikolaos Dabarakis & Ioanna Betsani, Greece

Introduction

Peri-implantitis is characterised by bleeding on probing, suppuration and radiographic evidence of bone loss.[1] The relevant literature has reported many methods for treating peri-implantitis.[2–6] Surgical access is recommended in defects of more than 2 mm in depth in order to achieve complete removal of granulation tissue and gain access for implant surface decontamination.[7,8] Many scientific articles have shown that the regenerative approach has better predictability when the presentation of the defect is infra-bony or circumferential.[9–11] Generally, methods of implant surface decontamination include mechanical debridement alone or in combination with saline, antiseptics, laser, photodynamic therapy, air–powder abrasion or implantoplasty.[2–6]

Recently, there has been a noticeable tendency towards laser application methods to vaporise the inflamed tissue in the peri-implant area and to detoxify the implant surface itself. The complicated peri-implantitis site consists of different kinds of tissue, as well as the titanium surface. This environment makes it difficult for the clinician to decide on method of treatment and the different tools required. Laser devices of different wavelengths are increasingly used, but only the erbium family of lasers can efficiently irradiate both soft and hard tissue and, moreover, the delicate implant surface. Under the correct parameters, erbium lasers can improve clinical outcomes by selective calculus removal, bactericidal and haemostatic effects, and titanium detoxification.[12–16] This case report will present a severe case of peri-implantitis that was treated with a therapeutic approach that combined a generative treatment using an Er,Cr:YSGG laser (2,780 nm) for debridement and decontamination.

Patient presentation

A 55-year-old male patient consulted our department for implant maintenance. The patient's medical history was clear, without any particular medical risk for dental care. Upon clinical examination, an implant in position #21 with a metal–ceramic restoration with pink porcelain on the cervical part was observed. The patient presented with suppuration, inflamed mucosa, deep peri-implant pockets (7–9 mm) and bleeding on probing. Radiographic examination showed vertical deficiency around the implant (Figs. 1 & 2). Excessive buccal implant positioning and flawed planning of the prosthetic restoration may have caused the condition at hand. Occlusal examination showed no equilibrated occlusal contacts on the mandibular teeth and traumatic interference. The patient's dentist had placed the implant three years earlier. At the time of initial consultation, he had already been on an antibiotic regimen for six days. The patient had had poor motivation but had not received proper instructions concerning plaque control techniques. One possible treatment option was removal of the implant, followed by bone and soft-tissue grafting and, finally, placement of a new implant. The alternative treatment option was to perform regenerative surgery in order to attempt to maintain the existing implant. The patient decided to proceed with the regenerative procedure.

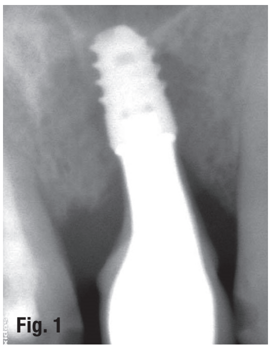
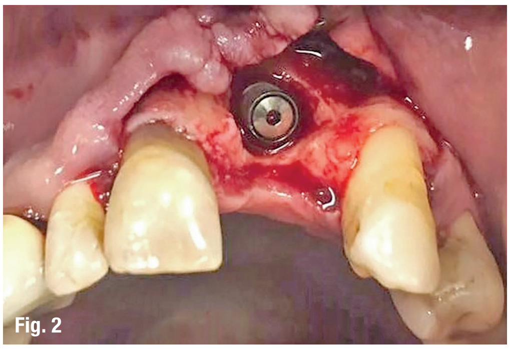


Fig. 1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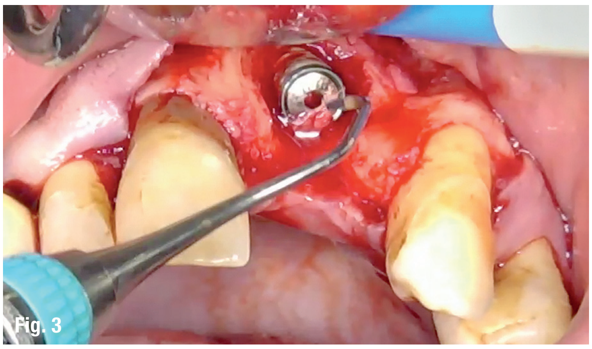


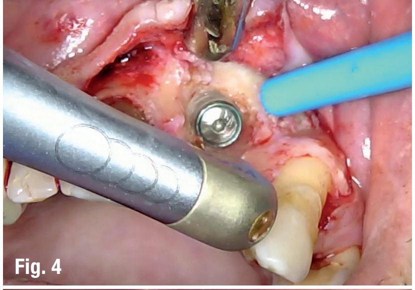
Fig. 3

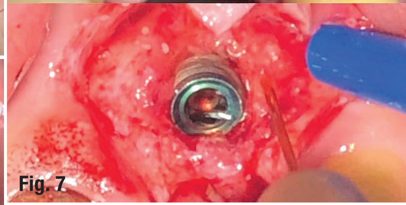
Figs. 1 & 2: Pre-op radiograph showing the initial clinical situation: excessive buccal implant positioning. **Fig. 3:** Mechanical debridement around the implant surface was done.

Treatment

After removing the existing abutment and prosthesis, a cover screw was placed for two weeks. Initially, intrasulcular incisions were made and a full-thickness access flap was elevated in order to have perfect access to the defect site. An initial mechanical removal of calculus and inflamed soft tissue around the implant area was performed (Fig. 3). An Er,Cr:YSGG laser (2,780 nm; Waterlase MD, BIOLASE) was used in order to thoroughly remove, through the ablation mechanism, calculus deposits and the granulated soft tissue in the area (Fig. 4). Two different tips were used with the gold handpiece of the device. An MZ6 tip (diameter of 600 µm, length of 14 mm) was employed with the following parameters: average power of 2 W, pulse repetition rate of 50 Hz, pulse duration of 140 µs (H mode), and 20 % air and 60 % water ratio. This was combined with the use of an RFTP5 tip (diameter of 500 µm) with the following parameters: average power of 1.5 W, pulse repetition rate of 30 Hz, pulse duration of 140 µs (H mode), and 40 % air and 70 % water ratio. The two different tips gave us the optimal combination for removing the inflamed soft tissue around the implant, detoxifying the area, including the osseous surfaces, and safely decontaminating the implant surface.

Along with the thorough debridement of the surgical site, decortication was performed to promote osteogenesis. A non-resorbable titanium membrane (Surgitime Titanium, Bionnovation) was stabilised with three cortical bone pins (one in the palatal site and two buccally), followed by placement of bone grafting material (EthOss, EthOss Regeneration). The titanium mesh acts as a mechanical barrier for guided bone regeneration (GBR), helping in the formation of new bone and avoiding cell migration from the epithelium. Also, it has been designed to ensure the 3D reconstruction of alveolar bone defects. EthOss is a combination of beta-tricalcium phosphate and calcium sulphate, creating a calcium-rich environment ideal for bone growth. The site was sutured with a 5/0 non-resorbable silk suture. The standard postoperative instructions were given to the patient, who was





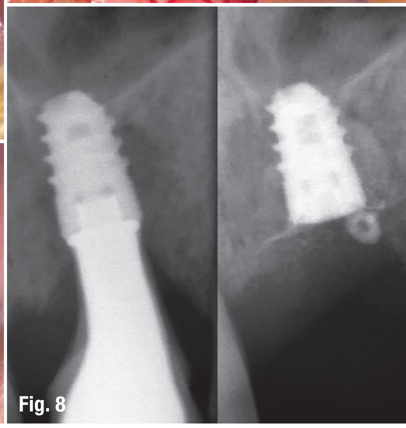
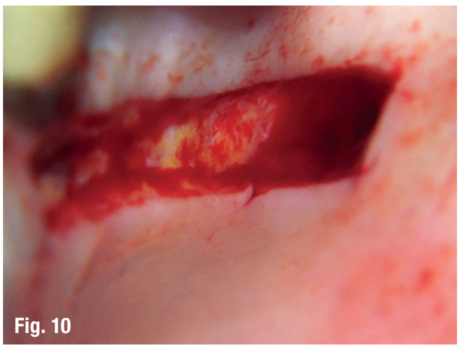


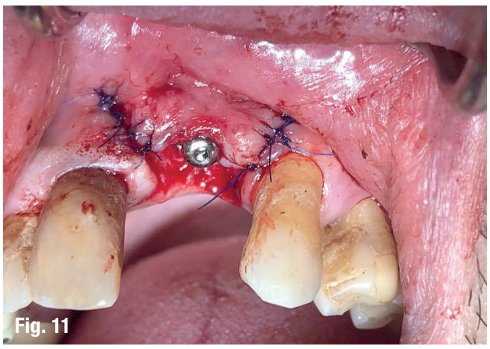
Fig. 4: Er,Cr:YSGG laser debridement around the implant surface was done. **Figs. 5 & 6:** Clinical situation six months after the GBR procedure. **Figs. 7 & 8:** Clinical and radiographic evaluation (initial situation and six months post-op).

recalled after 14 days for suture removal. At each subsequent visit every 15 days, oral hygiene instructions were reinforced. Six months postoperatively (Figs. 5 & 6), the non-resorbable titanium membrane was removed and soft-tissue augmentation with a connective tissue graft from the palatal site was performed (Figs. 9–11), increasing the amount of attached gingiva around the implant (Figs. 12 & 13). The radiographic examination showed good bone regeneration. Eight months after the regenerative procedure, the final prosthesis was placed (Figs. 14–16).

Results

The clinical results of the regenerative procedure showed a noticeable improvement in periodontal probing depth (4–6 mm) and in clinical attachment level at the nine-

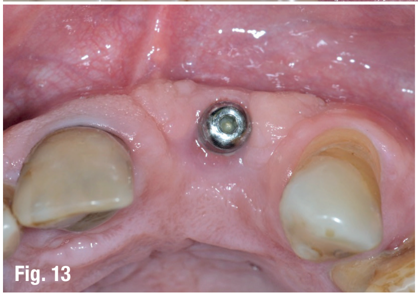




Figs. 9–11: Second surgical phase: placement of healing cap and soft-tissue augmentation around the implant using a connective tissue graft from the palate.


Fig. 12


Fig. 15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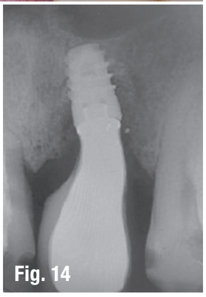
Fig. 14


Fig. 16

Figs. 12 & 13: Five weeks after soft-tissue augmentation. **Figs. 14 & 15:** Final restoration—radiographic and clinical examination showed an acceptable result for a compromised case. **Fig. 16:** The final clinical result.

month observation. Also, the absence of inflamed mucosa and bleeding on probing indicated a healthy periodontal condition in the regenerative area. Radiographic findings demonstrated the improvement of the bone deficiency in all peri-implant sites. The overall conclusion on the utilisation of Er,Cr:YSGG laser as an adjunct to peri-implantitis treatment is undoubtedly positive. It has been shown that erbium lasers cause no visible changes to the titanium surface under appropriate irradiation parameters.[17] Other *in vitro* studies have demonstrated that the ablation process through the use of water spray does not create temperature elevations of titanium during laser irradiation.[18] Finally, erbium lasers are capable of effectively removing calculus and plaque from contaminated abutments and removing biofilms grown on high-roughness titanium surfaces.[18, 19] The results are highly promising but—as a result of the variation of the parameters used in the studies—further clinical trials are needed to achieve a certain verdict.

Conclusion

This case has demonstrated the possibility of successfully treating severe peri-implantitis using an Er,Cr:YSGG laser. In this particular case, three factors played a crucial part in the final outcome: patient motivation, laser decontamination with effective GBR and the absence of traumatic jiggling forces in the surgical area. The access flap permitted successful Er,Cr:YSGG laser debridement and decontamination of the exposed implant surface. This was confirmed by the clinical and radiographic examinations. However, the final restoration may have been a compromise in terms of an optimal aesthetic outcome, but often clinicians must be mindful of the necessity of accommodating the patient's wishes. After the last re-evaluation at the six-month follow-up, the patient was included in an implant maintenance programme with regular visits for peri-implant probing and prophylactic implant scaling.

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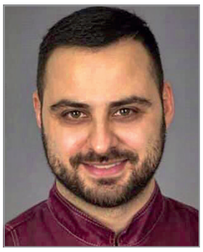
Dr Dimitris Strakas completed his M.Sc. in Lasers in Dentistry at RWTH Aachen University in Germany in 2006. In 2017, he obtained his PhD from the Aristotle University of Thessaloniki, and in 2013, he founded the laser clinic department there. Since 2017, he has been a university scholar in the Department of Operative Dentistry of the same university. He runs a private laser dental clinic in Volos in Greece. In addition, he is the Secretary General of the International Society for Laser Dentistry.



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Literature

Crown lengthening in the aesthetic zone

Comparing laser and conventional surgery

Dr Habib F. Zarifeh, DDS, MS, M.Sc.; Dr Nada El Osta, DDS, PhD;
Dr Dany Salemeh, MS & Dr Sami El Toum, PhD, Lebanon

In the following article, two methods for correction or reduction of minor gummy smile will be discussed: conventional surgery and laser-assisted surgery. The aesthetic outcomes of the two methods will be compared, and differences in pain, discomfort, swelling, predictability of the results and patient satisfaction according to the visual analogue scale will be discussed. It will be shown that crown lengthening with a dental laser can be a viable alternative to conventional surgery, for there are noticeable differences regarding postoperative complaints, and predictable and stable aesthetic results can be achieved this way.

Literature review

In the past, the conventional approach has been clearly and scientifically proved by sound studies, and there was a lack of technological advancements and the absence of new studies and evidence-based laser dentistry. The conventional techniques used were based on the severity or importance of the gummy smile. The correction of gummy smile was based on minor correction by bony crown lengthening of the smile line for the hard- and soft-tissue removal of the procedure. Advanced gummy smile correction cases were usually referred for orthognathic surgery, as described in the literature.[1–4] Today, supplementary techniques for gummy smile reduction, such as botulinum toxin and hyaluronic acid fillers of the upper lip, are also viable options for treating patients seeking cosmetic treatment.[5,6] Also, in some cases, lip repositioning can be advised in order to hide the excessive gingival display in the aesthetic zone.[7,8]

Materials and methods

Study population

The cases reported on in this article were part of a clinically comparative prospective cross-over study. Ethical approval was obtained from the ethical research committee of the Lebanese Dental Association of Beirut in Lebanon, and the patients signed a detailed consent form before undergoing the surgical procedure.

Description of the intervention

All surgeries were carried out by the same practitioner. The crown lengthening procedure was divided into two parts: performed from the midline of the maxillary central incisors to the second premolar area on one side using the conventional surgery technique and from the midline of the maxillary central incisors to the other second premolar area using the laser technique. The side for each technique in each patient was random selected. The patients were female, aged between 22 and 25, and perfectly healthy according to their medical histories. Moreover, they were non-smokers who rarely drank alcohol. Also, they had no allergies to any commonly used medications and took no daily medication prior to the treatment. Their family medical histories did not reveal any serious medical problems or anomalies. Most of the patients maintained remarkable oral hygiene.

Ahead of treatment, panoramic radiographs of the patients were taken. A detailed intra- and extra-oral examination was also done, including VELscope assessment (LED Dental) to check for oral precancerous lesions, and the findings were perfectly healthy intra-oral conditions of the cheeks, soft palate and tongue. Detailed probing was performed for every patient, from the distal part of the first right premolar to the distal part of the second left premolar. There were three points of probing for each buccal side of each tooth (distal, middle and mesial). The aim of the probing was to check the reattachment of the periodontal ligament after one month and compare it between the two techniques that were used. Measurements of the gingival surface for swelling assessment was done using the CEREC Bluecam digital scanner (Dentsply Sirona), comparing the 3D images before the surgery and after the first, second and third clinical assessment after the procedures (Fig. 1).

The laser technique

The following preoperative photographs were taken: a sagittal or frontal photograph perpendicular to the incisal edges of the maxillary central incisors and in the plane of the midline of the maxillary central incisors (Fig. 2), a lateral pho-






Fig. 1: Pre-op CAD/CAM photograph for swelling measurement. **Fig. 2:** Pre-op frontal view. **Fig. 3:** Pre-op right lateral view. **Fig. 4:** Pre-op left lateral view. **Fig. 5:** Pre-op occlusal view. **Fig. 6:** Laser soft-tissue removal.

tograph perpendicular to the buccal surface of the right canine (Fig. 3), a lateral photograph perpendicular to the buccal surface of the left canine (Fig. 4), and an oblique occlusal photograph at approximately 45° to the midline of the maxillary central incisors (Fig. 5). Detailed probing of the periodontal pockets was carried out, and the biological width of the ten maxillary teeth was measured and noted.

By means of the Er,Cr:YSGG laser, the patient's new gingival margin was drawn on to the gingival margin, starting from the distal area of the second premolar of one side to the distal area of the second premolar of the other side. The laser, operating at a wavelength of 2,780 nm, was set to 1 W, 0 % water, 0 % air, H mode (150 µs) and 50 pps, for dehydrating the marginal gingiva in order to limit the expected future gingival line.

After drawing of the future gingival line, 2–3 mm of soft tissue was removed using the Er,Cr:YSGG laser, operating at a wavelength of 2,780 nm and set at 4.5 W, 50 % air, 30 % water, H mode (150 µs) and 50 pps, in non-contact mode with a Z6 tip perpendicular to the gingival surface. There was a distance of 2 mm between the Z6 tip and the gingiva. After removing a few gingival layers and before achieving complete ablation of the gingiva, the tip was redirected and the second phase of the soft-tissue removal began with a tip direction parallel to the tooth surface with the same settings in non-contact mode and at a distance of 2 mm from the gingival margin in order to eliminate the amount of gingiva that was to be removed layer by layer (Fig. 6).

In the following step, hard tissue was removed in order to obtain a stable final result regarding the future gingival line. The Z tip was marked at 2 mm from the working side with a fluorescent marker. The surgical procedure was performed using the Er,Cr:YSGG laser, operating at a wavelength of 2,780 nm and set at 4.5 W, 50 % air, 70 % water, H mode (150 µs) and 35 pps, in non-contact mode, with a painting movement at a rate of approximately 60 seconds per tooth with the Z6 tip parallel to the buccal wall of the tooth. The working part of the tip was inside the sulcus and the previous sulcular depths of each distal, middle and mesial point of the buccal sulcus of each tooth were known. The objective was to restore the depth of the sulcus by removing the alveolar bone with painting movements to the point of x –1 mm of the selected marker, where x was defined as the preoperative sulcular depth. The bony crown lengthening was stopped at –1 mm, since the Er,Cr:YSGG laser, operating at the described settings, has a working distance of 1 mm ahead of the working tip of the Z6 tip, and the painting movement aims to maintain the polished surface of the remaining alveolar bone as much as possible.

The conventional surgery technique

The incision of the soft tissue was done with a #15 blade, starting with a 1 cm incision parallel to the midline of the maxillary central incisors, proceeding perpendicular to the surface of the alveolar bone and redefining the new gingival line with another incision going mesial from


Fig. 7


Fig. 8


Fig. 9


Fig. 10


Fig. 11


Fig. 12


Fig. 13

Fig. 7: Scalpel alignment of the future gingival line in the conventional surgery site. **Fig. 8:** Soft-tissue removal in the conventional surgery site. **Fig. 9:** Full-thickness flap and retraction of the periosteal membrane. **Fig. 10:** Suturing and final photograph immediately after surgery. **Fig. 11:** Clinical situation three days after surgery. **Fig. 12:** Clinical situation seven days after surgery. **Fig. 13:** Clinical situation one month after surgery and after placement of the veneers.

the central incisor to the distal wall of the second premolar of the same side and always parallel to the previous limit of the gingival margin of the sulcus (Fig. 7). The soft tissue defined by the previous incision was removed (Fig. 8), a full-thickness mucoperiosteal flap was performed (Fig. 9), and bony crown lengthening or alveolar bone removal was performed with a round diamond bur. The amount of removed bone should be equivalent to the amount of removed gingival tissue in each tooth. This should be defined ahead of surgery with probing of the sulcus and aesthetic assessment when planning the future gingival line of the patient. Suturing was done using 4/0 resorbable silk sutures (Fig. 10).[9–13]

After the surgery, we prescribed an antibiotic (Augmentin, 625 mg; one tablet twice a day for seven days), a non-steroidal anti-inflammatory drug (ibuprofen, 400 mg; one tablet twice a day for three days) and an analgesic (paracetamol, 500 mg; two tablets twice a day for one day). Clinical assessment was performed on a daily basis for three days (Fig. 11) after the procedure, a fourth clinical assessment after one week, on the same day as the sutures were removed (Fig. 12), and a final reassessment after one month (Fig. 13) in order to recheck and compare the reattachment of the periodontal ligament.

Results

On the third day, no significant difference was found between the conventional and laser surgery groups (p-value = 0.364; Wilcoxon test) according to the visual analogue scale. The fact that we can achieve with laser surgery in three days what we can achieve with conventional surgery in seven days regarding the swelling parameter is significative. In the first few days, redness of the tissue can occur. The tissue adjacent to the treated areas may feel tight. In the conventional surgery site, redness of the gingiva was present during the healing period. In the laser surgery site, however, gingival redness was close to negligible owing to the conservative, non-aggressive, selective removal of the soft and hard tissue. The reason for such gingival redness is the inflammatory process of the regeneration of the new epithelial and connective tissue cells. However, one week after the procedure, the two sites revealed similarities in terms of structure and bleeding, which were close to negligible.

The texture of the newly formed gingiva was approximately the same one week after the procedure for the two compared techniques. In the laser-treated site, the tissue had reattached normally, unlike in the conventional surgery site. This can play a very important role in the predictability of the results of the Er,Cr:YSGG laser, especially when it comes to the aesthetic zone and participants' desire for reduced gingival display while smiling. Laser treatment reduces the formation of scar tissue due to tissue damage related to cuts, burns and surgery. This therapy can reduce the formation of fibrous tissue by accelerating the healing process, improving the blood flow to the treated area. It must be noted that fast healing leads to less scar tissue formation.[14]

Discussion

The purpose of this study was to evaluate the Er,Cr:YSGG laser approach for crown lengthening of soft and hard tissue in the aesthetic zone with a view to the aesthetic outcome for patients with minor gummy smile. The results of the study show that laser-assisted crown lengthening in soft and hard tissue must be considered a viable alternative to conventional surgery owing to its numerous advantages. For instance, though the use of the Er,Cr:YSGG laser in flapless crown lengthening surgery, postoperative symptoms can be minimised, such as swelling and pain, which are due to the unnecessary retraction of the periosteal membrane, leading to inflammatory cells collecting for regeneration of the periosteum after surgery. Also, the mechanical removal of bone with conventional rotary burs can lead to heat damage to the bone, even if there is additional water cooling by the handpiece. The removed part of the bone will simultaneously have dead bone cells on top of the alveolar crestal bone and consequently additional inflammatory cells, which can lead to additional swelling and to delayed healing of the bone and gingiva.

In terms of healing, the use of an Er,Cr:YSGG laser for soft-tissue removal has tremendous advantages over the scalpel procedure. For one, the Er,Cr:YSGG laser does not lead to damage to the epithelial and connective tissue, as it removes layers of the gingiva by explosive evaporation; thus, this approach will not lead to inflammation and gingival bleeding is minimal. Retraction of the periosteal membrane and bone and gingival removal with conventional surgery require sutures, which can irritate the mucosa of the upper lip. Also, most of the patients complained about pain caused by the midline suture, similar to complaints after frenectomy of the upper labial frenulum.

Reattachment of the hemidesmosomes and regeneration of the periodontal ligament are also affected by the conventional surgery procedure. In the conventionally treated case, there was delayed reattachment and inconsistent probing pocket depths one month after the surgery. The Er,Cr:YSGG laser in the laser-assisted surgery, however, contributed to a sterile surface of both the cementum and the periodontal ligament, leading to better, quicker and smoother reattachment as a result. The deepest layers of the connective tissue and the epithelium were also positively affected by the use of the Er,Cr:YSGG laser, similar to a biostimulation effect. The layers of the gingiva appeared to be healthier, and the colour and texture were more suitable for the newly formed gingiva. The hygiene of the patients treated with conventional surgery was also affected: the participants complained about having noticeable discomfort while brushing the surgery site. The patients treated with the laser, however, did not feel any of this physical discomfort. Noticeable sensitivity of the teeth was also described by the participants treated conventionally, while the laser-treated patients did not feel such sensitivity either.

Conclusion

The use of an Er,Cr:YSGG laser for crown lengthening in soft and hard tissue achieves a similar aesthetic treatment outcome compared with conventional surgery. The postoperative symptoms of the conventional approach, such as pain, swelling and physical discomfort, can be minimised through the use of a dental laser. Also, the use of this laser is very helpful for correctly predicting treatment outcomes, and quicker reattachment of the periodontal ligament, specifically in the aesthetic zone, can be achieved as well.

Literature

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Dr Habib F. Zarifeh is a Lebanon-based dentist specialised in Oral Surgery, Aesthetic and Laser Dentistry. He is the head of the dental division at the Clemenceau Medical Center affiliated with Johns Hopkins International and the founder of Smile Infinity International. He completed his M.Sc. in Lasers in Dentistry at the RWTH Aachen University in Germany.

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Photoacoustic cavitation effects in oral surgery

How to preserve tissue and promote healing

Dr Evgeniy Mironov, Bulgaria

Introduction

The solid-state lasers used in dentistry were invented almost 30 years ago and they were initially aimed at creating new possibilities for the treatment of both hard and soft tissue with less tissue loss and mechanical or acoustic stress. Erbium lasers showed the highest potential for gentle but effective all-tissue treatment,[1] owing to their high absorption in water and hydroxyapatite. With technical improvements and power setting updates, Er:YAG and Er:YSGG also became popular for oral surgery and periodontics. Mid-infrared lasers are able to treat inflamed soft tissue, clean the root surfaces and cut the bone, subsequently stimulating bone regrowth.[2–4] Another benefit is simultaneous decontamination due to release of oxygen radicals and local high temperature peaks. With especially designed tips, bone cutting and contouring are possible in non-contact mode, thus eliminating vibration stress, which is important in procedures like sinus lift or peri-implantitis flapped surgery. The next level in surgery that employs erbium laser fluence is 3D cleaning, generated by photoacoustic waves in fluids. The cavitation effect is caused by activating the water molecules with subablative energy levels of radiation. This kind of interaction allows cleaning and decontamination of bone walls that are difficult to reach, as well as implant and root surfaces, at the same time, without risk of damaging them.

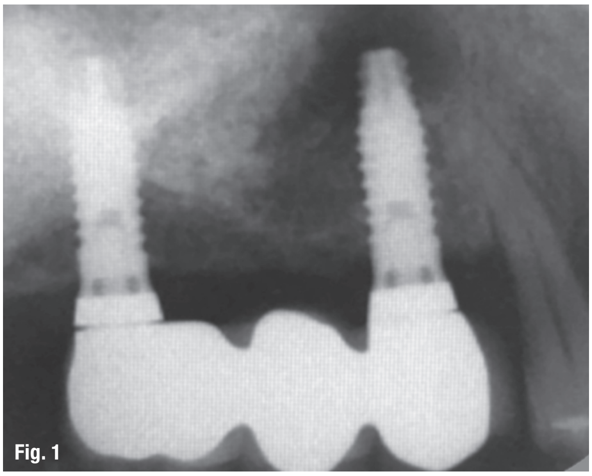
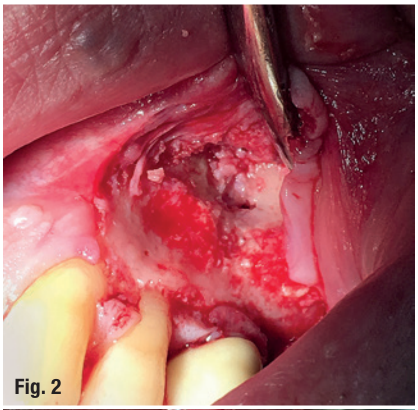


Fig. 1: Pre-op radiograph: despite the large area of osteolysis, the implants did not show any signs of inflammation. Tooth #24 was vital.

The physical phenomenon of cavitation is observed on surfaces in contact with non-stationary water content, while in experimental environment first is induced with ultrasonic activation. A series of explosions and implosions of formed bubbles towards the surface cause fast movement of the vapour and liquid and subsequent changes at the contact points. Thus, activated by subablative levels of Er:YAG (Er:YSGG) energy, water-based solutions can be used as a mediator to clean hard and soft tissue and implants of debris, granulations, biofilm and other loosely adhered substances. In laser dentistry, cavitation was first introduced as a method for irrigation of and debris removal from the root canal system. While some clinicians use high energies with specially designed tips in the canals with moderate thermal effects,[5,6] others limit the action to the pulp chamber with low energies, reaching all parts of the endodontic system only through activation of the solution, caused by the photoacoustic effect of the Er:YAG laser.[7]

From a surgical stance, erbium laser cavitation is revolutionary, as this physical phenomenon allows the clinician to reach zones and structures in surgical sites that are otherwise unreachable using different means. Areas like the bone around the implant thread or behind the root apex, or undercuts in cysts or granulomas, and the deepest parts of periodontal pockets are impossible to treat directly without sacrificing large quantities of healthy bone, or damaging the roots or implant surface. Hence, when we add photoacoustic liquid activation to our surgical protocol in cleaning the inner part of periodontal or bone defects, in peri-implantitis treatment or in apicectomy, we can minimise the extent of intervention with the same cleaning and disinfection effect. Usually, cavitation is performed as part of flapped surgery, but in some periodontal cases, it is possible to employ it in a closed manner with activation of specific solutions, such as metronidazole or saline.



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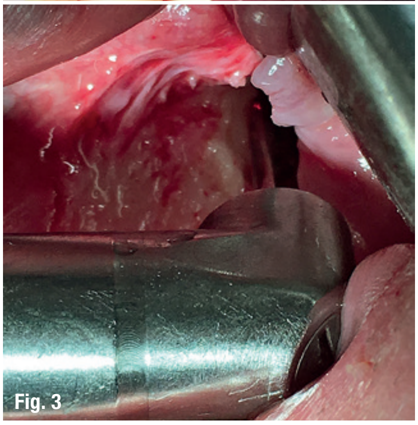

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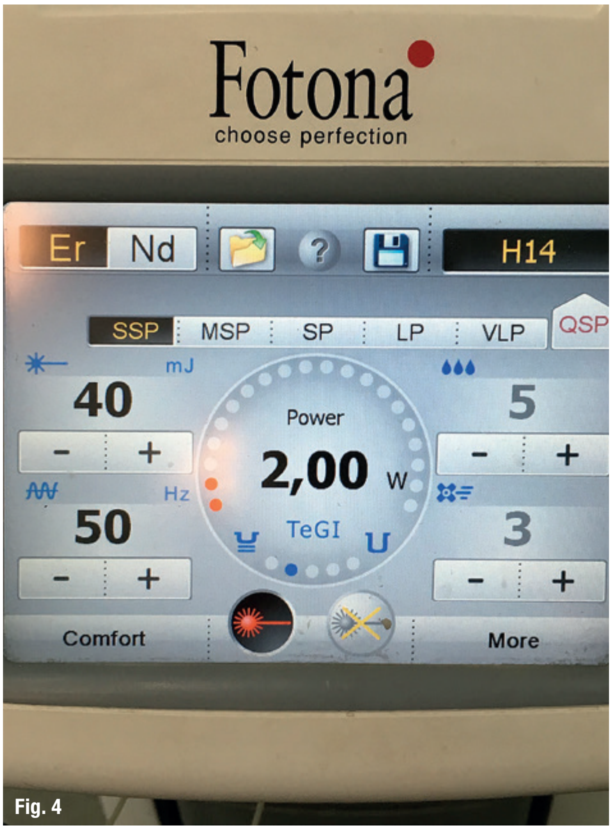

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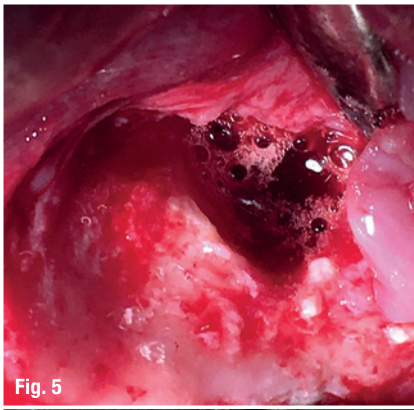

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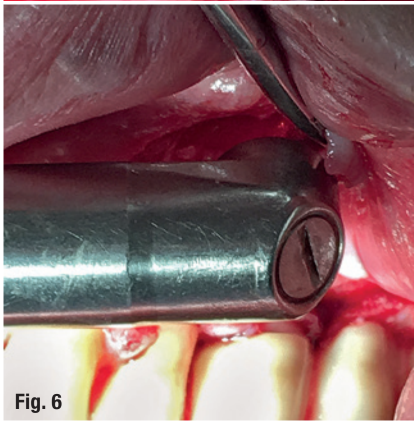


Fig. 6

Fig. 2: Upon uncovering the bone lesion, non-resorbed, unintegrated parts of bovine bone were observed. **Fig. 3:** Using sufficient water spray when working with high energies is quick and safe and helps granulation tissue to flow out. **Fig. 4:** It is important to stop the laser, water and air and activate just the saline, injected into the defect. **Figs. 5 & 6:** Cavitation cleaning effect.

Materials and methods

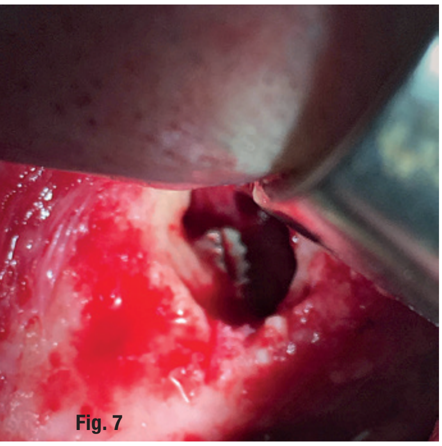
In the cases described in this article, the Er:YAG lasers LightWalker AT (Fotona) and LiteTouch (Light Instruments) were used. The only common denominator of these dental laser systems is the wavelength, which is 2,940 nm. Fotona uses an articulated arm with a mirror system for the energy delivery with a Gaussian beam profile. The LiteTouch system features Laser-in-Handpiece technology with a minimal energy transfer path and flat-hat beam profile. This profile enables very smooth and gentle interaction with soft and hard tissue, resulting in no ruptures or loose micro-parts, which is of great benefit for cutting soft tissue (with a special scalpel tip) or bone shaping, as it produces less swelling and promotes good healing. A Gaussian profile creates a peak of energy in the centre of the treated tissue spot, leading to micro-disruptions and -cracks at high energies. However, this method is much more effective when large volumes of tissue are to be removed without thermal effects. To avoid tissue stress, energy levels have to be reduced when approaching healthy tissue.

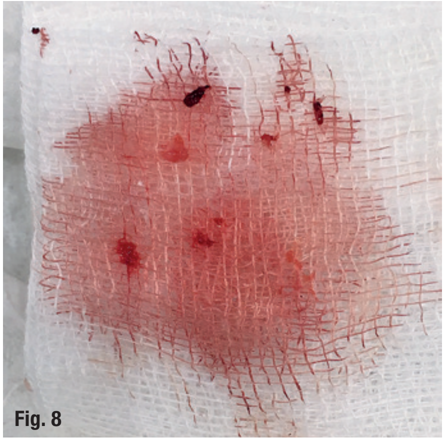
The LightWalker system includes six different pulse length settings (including QSP mode, a secondary sequenced pulse mode with a high hertz rate). Also, there is the option of choosing very low energy levels, like 25 mJ and 50 Hz in SSP mode (50 µs). With LiteTouch, one can choose between soft- and hard-tissue mode. For these, there are fewer options for parameter settings. However, there are energy levels well linked with repetition rate, and these can be quickly set and changed during surgery. For surgical cavitation procedures, both companies offer conical tips with a 0.8 mm aperture, which is ideal for treating large volumes of liquids, for which more energy is required. For closed periodontal pocket decontamination and cleaning, a 0.6 mm fibre should be used with power of less than 1 W.

The patients who underwent the procedures described in this article were informed about the specific characteristics of the Er:YAG laser. They were also given a demonstration of the laser effect on an implant sample, comparing this treatment to a classical surgical approach. After forming their decision, informed consent forms were signed.

Case 1: Apical peri-implantitis

A male patient presented to the practice who had had multiple teeth extracted and undergone augmentation with bovine bone owing to severe periodontitis 1.5 years





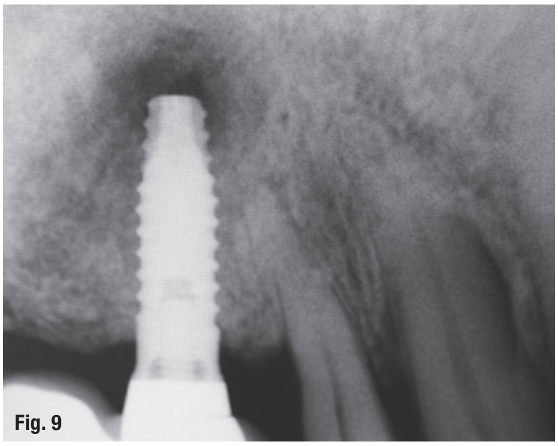
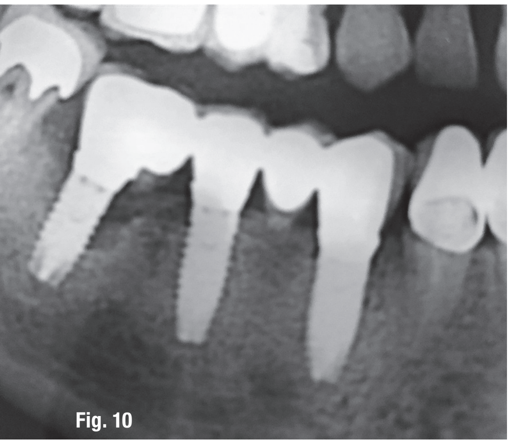
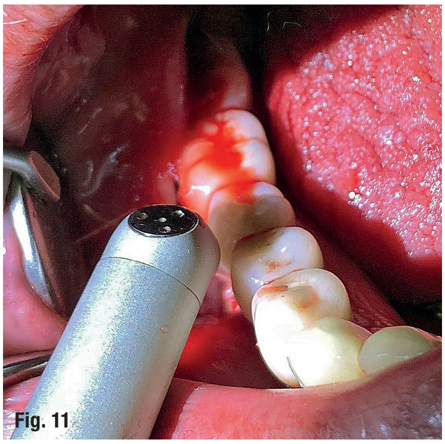


Fig. 7: Clean and non-damaged implant. **Fig. 8:** Granulation tissue collected. **Fig. 9:** Almost total bone regrowth after four months. The neighbouring teeth were not affected.

prior to his visit to the practice. Preoperative radiographs were taken, and these showed that the bone structure was homogenous. The graft also appeared to be integrated and thus the decision for an implantation was made. Four Z1-Connect tissue-level implants (TBR) were placed on both sides of the posterior upper jaw, and after five months, they were functionally loaded with three-unit porcelain-fused-to-metal bridges. Three months later, the patient reported pain while eating, especially in the zone over the implant in position #25. Upon radiographic examination, granuloma-like osteolysis was detected around the apex of the implant (Fig. 1). A full-thickness flap was raised and the bone lesion was accessed by means of an Er:YAG laser (LightWalker) with a 1.2 mm cylindrical tip and set to MSP mode (120 µs), 20 Hz/250 mJ, water 5 and air 3 (Fig. 2). The internal surface of the flap was degranulated in LP mode (300 µs) with parameters set at 20 Hz/200 mJ, water 5 and air 4, prior to bone preparation. After the defect exposure, the accessible inner walls were cleaned using the same tip, again in MSP mode, but this time set at 15 Hz/250 mJ. The lower frequency helps to avoid possible thermal effects due to heat accumulation (Fig. 3).

Performing an apicotomy of an implant is not possible with a standard surgical protocol, considering the possible cutting of the implant apex with burs. The exposed titanium surface was cleaned with safe settings (SSP mode [50–60 µs], 40 Hz/50 mJ, air 3 and water 5); however, the rear part of the implant and the back walls of the bone defect are unreachable this way. A hydro shock-activated saline solution effectively removed the debris and inflamed soft tissue through the cavitation effect in a closed space (Fig. 4). Ten to 15 cycles of cavitation with saline injection and subsequent activation were sufficient to clean all the hidden surfaces in this complex surgical wound (Figs. 5 & 6). It can be assumed that the wound is clean once there is no longer any granulation tissue coming out, nor massive bleeding, just clean blood that accumulates and forms a clot (Figs. 7 & 8). On a control radiograph





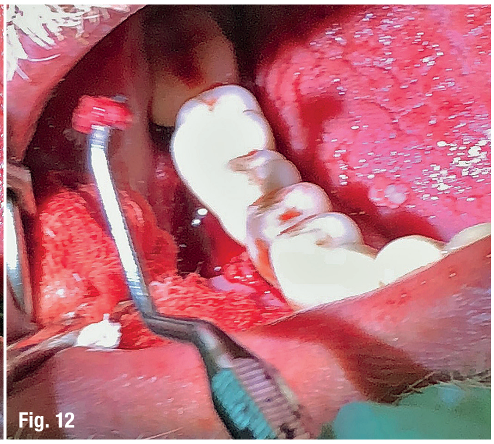


Fig. 10: Initial signs of peri-implant inflammation also notable around implant #44. **Fig. 11:** With a repetition rate of over 30 Hz, LiteTouch shows a cutting efficiency similar to that of near-infrared diode lasers, but without blood supply dependence. **Fig. 12:** The defect was wide enough to clean the inflamed tissue with a surgical curette.

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taken four months after the surgery, it could be seen that new bone had formed around the implant (Fig. 9).

Case 2: Severe marginal peri-implantitis

A 63-year-old patient complained about swelling and pus secretion from the gingivae near a bridge on three implants. Upon examination, marginal peri-implantitis was detected in the region of positions #45–47, and there was pus flowing out of the 7–8 mm pockets around the implants. Also, bleeding on probing was present around all implants in this area. A radiograph revealed bone resorption mainly around position #47, which corresponded with the finding of the intra-oral examination (Fig. 10). For this case, a new model of the LiteTouch Er:YAG laser was used. The incision was made with a scalpel tip at 40 Hz/100 mJ in soft-tissue mode (Fig. 11). This mode allowed a quick and smooth cut, without contacting the bone. An excellent healing line could be seen after eight days. If one wants to cut with the laser in a flapped surgery, de-epithelialisation must be ensured prior to raising the flap. After preparation of the vestibular part, the inner surface of the flap was degranulated at 20 Hz/200 mJ in soft-tissue mode. Alternatively, this can be done closer to the bone at 20 Hz/100 mJ in hard-tissue mode. The large volumes of granulation tissue that could be reached around the implants were removed manually (Fig. 12).

In the next phase, the rest of the inflamed tissue was removed using a hard-tissue pulse length at 15–20 Hz/250 mJ with a water and air spray and conical or chisel tips (Fig. 13). The amount of bleeding was tolerable and clean bone edges were present; thus, the procedure commenced with cavitation-based cleaning of the visible and unreachable zones (Fig. 14). For cavitation, saline should be forced into the bone chamber around the implant. Overflow serves as a shield against spattering blood and solution and lends effective fluence to the liquid (Fig. 15). In hard-tissue mode, 40 Hz/50 mJ and spray off, photoacoustic activation was performed more than 15 times until no more granulation tissue came out and a clean clot started to form (Figs. 16 & 17). In a final step, an allograft was used to fill the bone defect (Fig. 18). The bridge was not fixed right after the surgery, but after the stitches had been removed (Figs. 19 & 20). On a control radiograph taken after four months, it could be seen that new bone had formed and there were no clinical signs of infection or alteration of the surrounding tissue (Figs. 21 & 22).

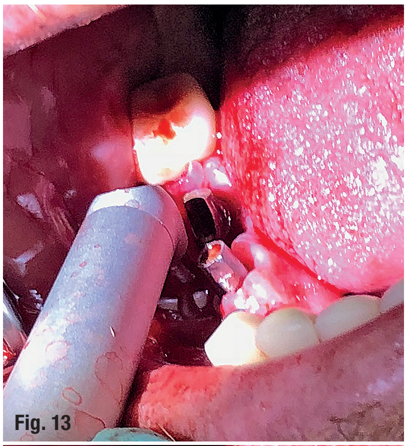
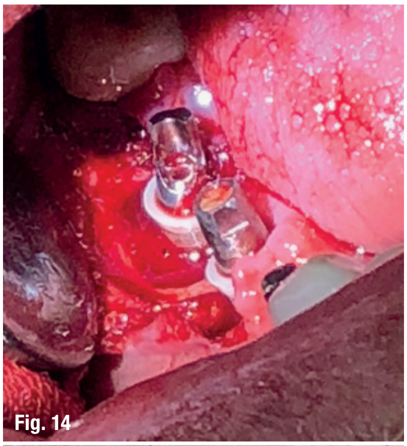


Fig. 13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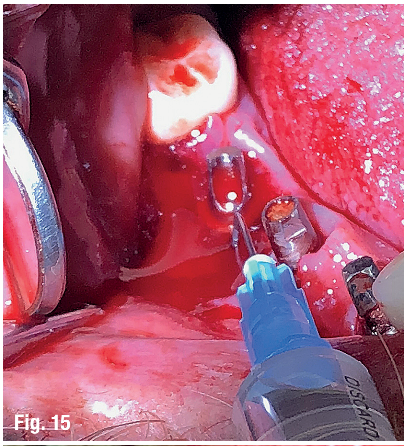
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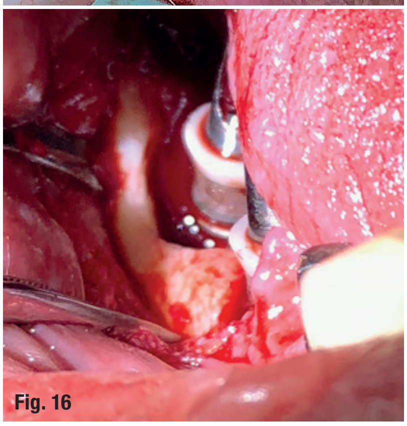
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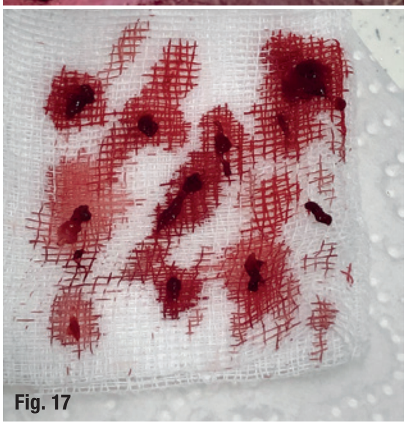
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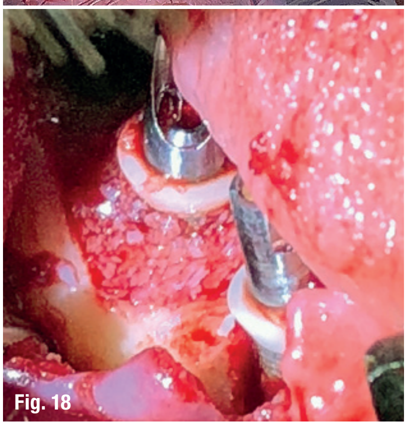
Fig. 18

Fig. 13: Removal of the bridge ensured direct access to all areas of the bone wound. **Fig. 14:** Adequate clot formation is demonstration of well-cleaned bone and soft tissue. **Fig. 15:** Two implants were treated simultaneously. **Figs. 16 & 17:** The implant surface was clean, bleeding was negligible and a clot was forming. A great deal of granulation tissue was evacuated just by cavitation. **Fig. 18:** Human bone from a tissue bank was used for grafting.

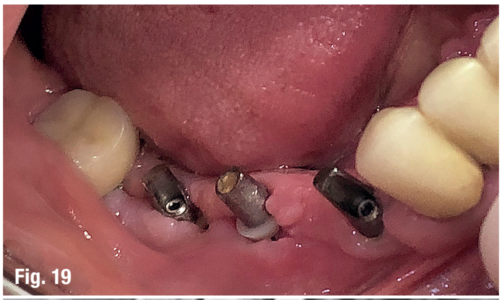
Fig. 19


Fig. 20

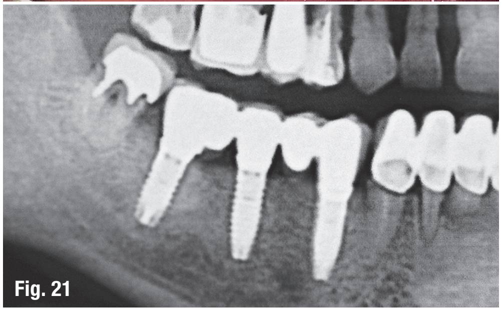
Fig. 21


Fig. 22

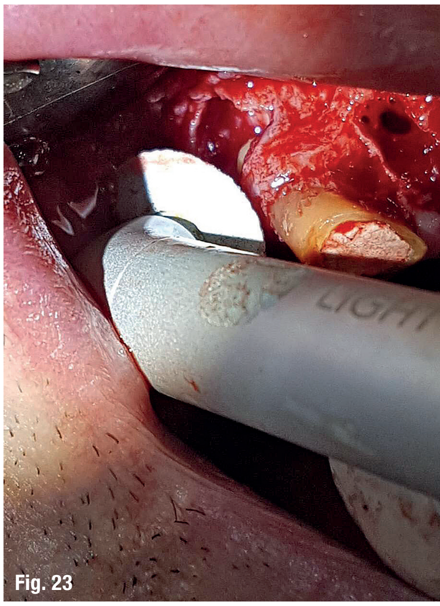
Fig. 23

Figs. 19 & 20: Almost no visible cutting line after eight days. The bridge was fixed with temporary cement. **Figs. 21 & 22:** Radiographic and clinical appearance after four months. **Fig. 23:** Rubber shield used to prevent saline solution spraying out.

Conclusion

To finalise this short demonstration of the power of the subablative energy of the Er:YAG laser, well mediated by liquids, is a discussion of the benefits of this technique. First, there is no direct contact and no risk of thermal damage or vibration stress. Owing to low energy levels, there are no loud sound effects compared with standard intervention in bone, making patients calmer and more relaxed. In addition, structures can be treated that are otherwise almost unreachable with tips for direct intervention, plus the chemical effects of cleaning solutions are used. Apart from that, it is a minimally invasive tissue-saving procedure that is much easier to carry out for general practitioners than a classical surgical approach. Lastly, there is no risk of maxillary sinus membrane rupture during treatment in proximity.

However, there are also downsides to this procedure: fast evacuation of the liquid in cases of shallow defects, for which there are some solutions at present (Fig. 23). According to clinical experience, the repetition rate is more important than the energy level for the fast activation and overflow of the mediator. For defects that are difficult to reach, a hertz rate of between 20 and 30 at 40 mJ is recommended. Cavitation treatment can be added to every surgical protocol in bone and soft tissue, owing to its simplicity and no additional preparation requirements—even at the end of any procedure—instead of standard saline rinsing. Further upgrades to this technique in oral surgery are to be expected from engineers and dental laser manufacturers in the future, meeting the complex needs for effectively treating different and unpredictable shapes and volumes.

Literature

about the author

Dr Evgeniy Mironov is a dentist and internationally published author from Bulgaria. He graduated in dentistry from the Medical University–Sofia in Bulgaria in 2002. Since 2003, he has been practising general dentistry in his own private practice and has a special interest in aesthetic dentistry, implantology and oral surgery. In 2013, he completed the Master of Science in Lasers in Dentistry programme at RWTH Aachen University in Germany. He lectures annually at the International Laser Dental Academy in Plovdiv in Bulgaria, and Deutsche Gesellschaft für Laserzahnheilkunde (German association for laser dentistry) and International Society for Laser Dentistry congresses, and at events hosted by dental laser manufacturers in Bulgaria and Slovenia. He is a member of the International Society for Laser Dentistry.

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The Dr Mir laser-assisted dental implant technique

A novel clinical approach

Dr Maziar Mir & Prof. Norbert Gutknecht, Germany

Since the 1970s, implant dentistry has revolved around the key idea that an incision in the gingiva has to be made in order to successfully place an implant. However, many surgical kits today feature a punch tool and many clinicians recommend punching a hole into the gingiva, in which the implant should subsequently be placed. Yet, there are also many clinicians who do not believe in the clinical benefits of this technique, since they believe that this method results in too large an amount of soft tissue in the implant bed, reducing the possibility of successful osseointegration as a consequence. Moreover, many do not believe in laser-assisted dental treatment because of the high risk of inducing tissue necrosis. Between 2003 and 2006, the author of this case report researched modalities for efficiently ablating hard tissue. In several projects, he and his team observed the interactions of the Er:YAG laser with hard tissue[1] and found that the Er:YAG laser is able to efficiently ablate both soft tissue and bone using laser-induced shock waves and photoacoustic interactions with short-pulsed laser light (Figs. 1a & b). Based on these findings, the author of this article developed the Dr Mir laser-assisted dental implant technique.

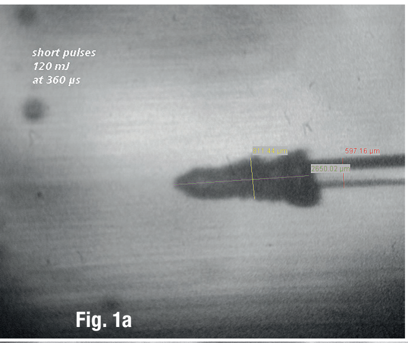


Fig. 1a

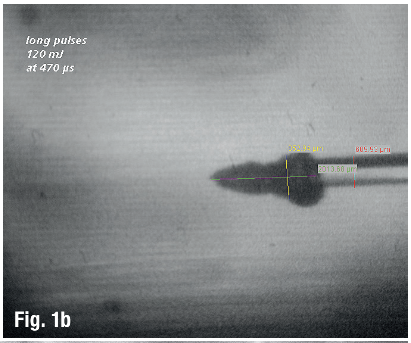


Fig. 1b

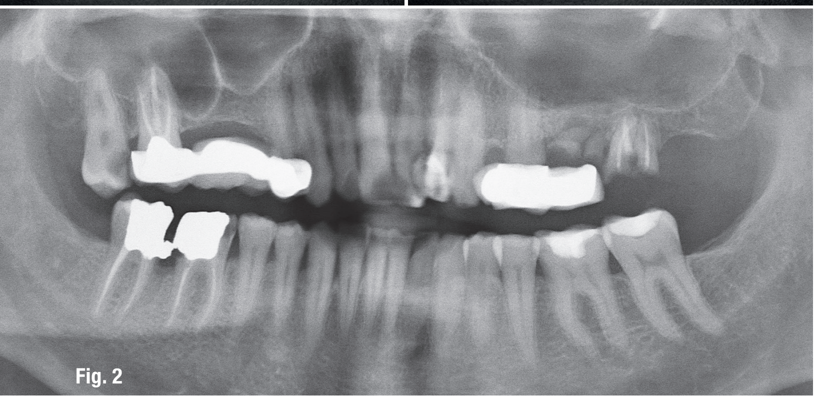


Fig. 2

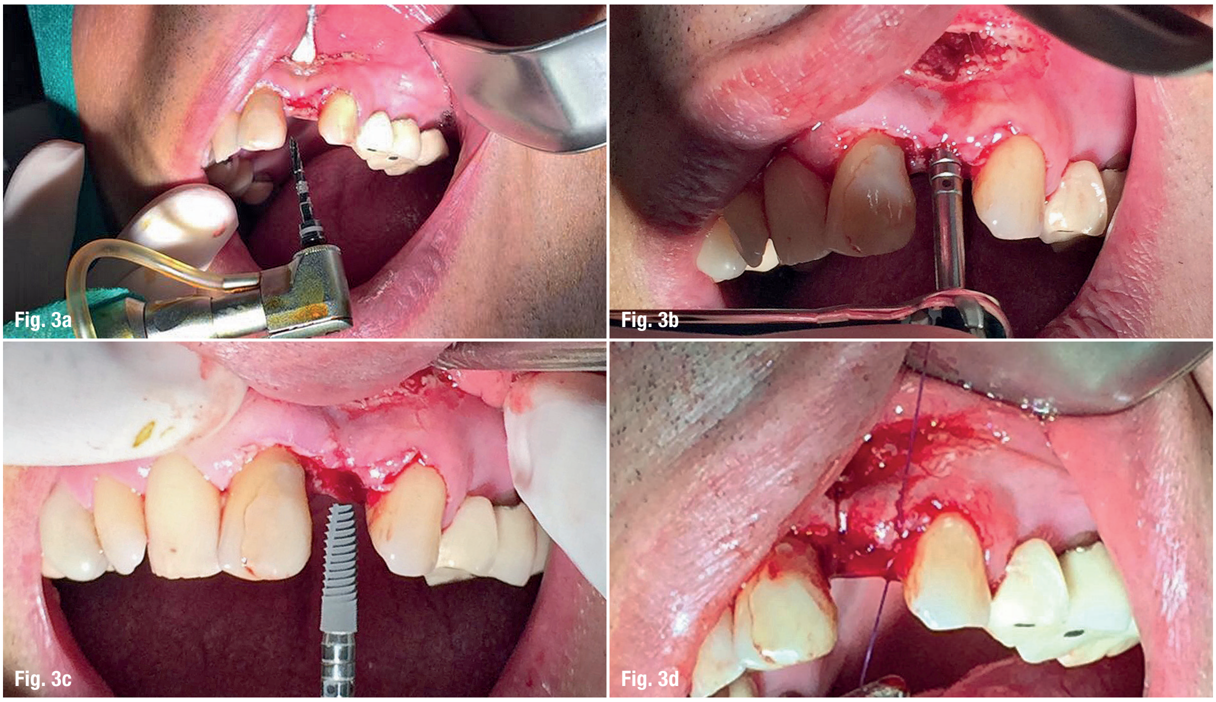
Figs. 1a & b: Samples of laser–water interaction captured by high-tech camera: water absorbs Er:YAG laser light and a bubble is formed. Its collapse leads to a shock wave, which is the basis for cutting water-containing tissues.
Fig. 2: Radiograph taken prior to the surgery.

On the technique

The Dr Mir laser-assisted dental implant technique is used for implant restorations. It uses very low amounts of laser energy and can be combined with incision techniques, punch techniques and a modified vestibuloplasty in order to achieve optimal soft-tissue management during surgery. The technique requires two surgical appointments. At the first appointment, a laser with an energy density of 9 J/cm^2 is used for semi-punching the soft tissue and the bone in order to create the implant bed. The implant is then inserted into the osteotomy. At the second appointment after two months, the definitive restoration is done. During this appointment, a laser with a lower energy density of 4 J/cm^2 is used in order to promote immediate healing. When the author of this article was in the early stages of developing this unique technique, he usually punched the gingiva with any laser he had at his disposal, which is why he argues that his method can be used with any dental laser type on the market, as long as low energy density is used in order to reduce the risk of creating irreversible changes to the tissue. The author recommends his technique being used for restorations in the aesthetic zone.

Case report

A 45-year-old male patient presented who had previously lost the crown of his maxillary left lateral incisor. It is for this reason that the patient requested a single-tooth implant restoration. However, it was important to him that there would not be any pain involved. Suffering from dental phobia, he had not been to a dentist to have his

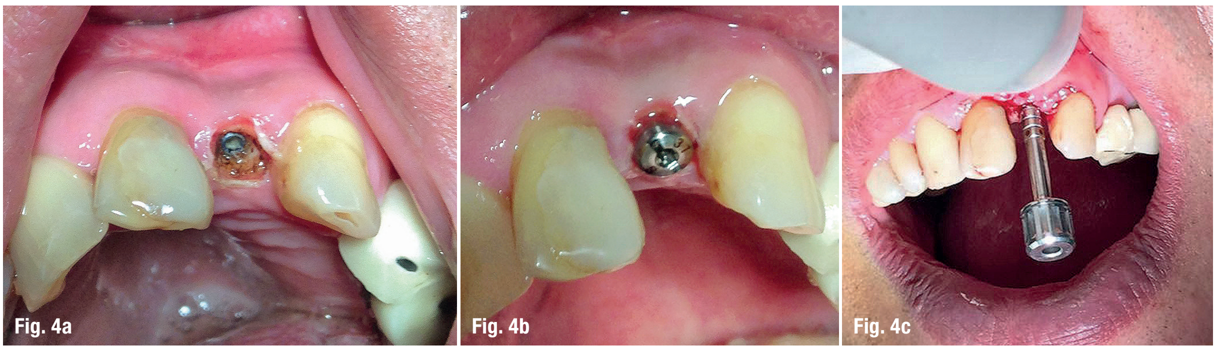


Figs. 3a–c: The osteotomy was prepared and the implant was placed using the Dr Mir laser-assisted dental implant technique. **Fig. 3d:** The surgery site was closed with aesthetic sutures in order to increase the attached gingiva and to support the formation of interdental papillae.

teeth checked in more than 20 years. At the beginning of the treatment, a radiograph was taken and the surgery was digitally pre-planned (Fig. 2). The bone was then prepared using laser-induced shock waves. In addition, soft-tissue management proved to be the key to success for achieving highly aesthetic results. The final drilling was done, and the Dr Mir laser-assisted dental implant technique was then employed for surgery using 9 J/cm^2 laser irradiation. The implant was placed according to the recommendations of the implant manufacturer (Figs. 3a–d). At the second treatment session, which was carried out two months after the initial appointment, the healing cap was removed and the abutment was seated (Figs. 4a & b). A laser set to 4 J/cm^2 was used to form the gingival margins and an impression was taken of the same area (Fig. 4c). The laser was used in a sweeping motion around the cover screw in order to promote immediate healing. After a few days, the digitally designed crown was placed (Fig. 5). After five years, the patient came to the follow-up appointment fully satisfied with his implant (Fig. 6). He even considered undergoing further implant surgeries in the posterior area in the future.

Discussion

The technique introduced in this article can be carried out using various lasers. If an Er:YAG laser is used, however, it should be set to SWEEPS mode, as this has proven to be the best setting for removing the debris of soft tissue from the extracted tooth socket in order to increase the success rate of immediate implantation. The SWEEPS mode (shock wave enhanced emission photoacoustic streaming) uses the power of the Er:YAG laser to create non-thermal photoacoustic shock waves



Figs. 4a–c: After a successful healing period, the abutment was placed and an impression was taken at the second appointment.

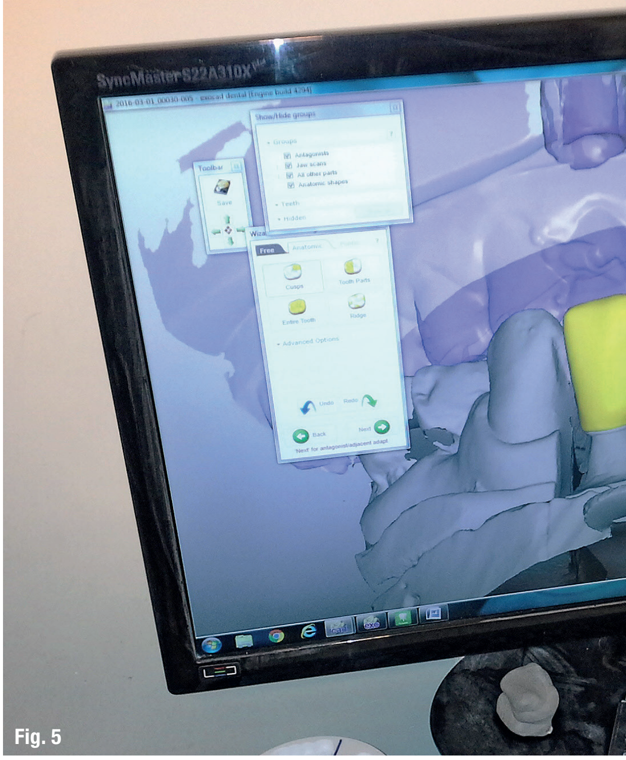


Fig. 5

Fig. 6

Fig. 5: The crown was digitally designed using CAD/CAM software.
Fig. 6: The result at the follow-up after five years was highly aesthetic.

within the cleaning and debriding solutions introduced in the bone that is prepared for implant insertion by QSP (Quantum Square Pulse). It is suggested that preparing bone with QSP mode is safer, for it achieves five shorter pulses with the same energy but with significantly higher peak powers. This makes it possible to work with low energy but with high peak powers, higher precision and higher speed, compared with other hard-tissue pulsing modes for other lasers. Higher energy density and higher peak power ensures cold, effective ablation, resulting in less thermal damage and less pain. Moreover, a common problem that might lead to implant failure is that microscopic particles of soft tissue can be pushed inside the prepared bone. With SWEEPS mode and the PIPS protocol (Photon-Induced Photoacoustic Streaming), soft tissue particles can be removed from the prepared bone area with the Er:YAG laser before the implant is inserted. In this case, the procedure was carried out with an energy density of 9 J/cm^2 for semi-punching both the soft tissue and the bone during the first surgery session. At the second appointment, the laser was set to a lower energy density of 4 J/cm^2 in order to aid immediate healing. Dental lasers have a variety of clinical benefits, not only for the clinician but for the patient as well. Laser irradiation with a low energy density has proven to have analgesic effects. In addition, it decreases inflammation and accelerates the healing process owing to its biostimulating properties.

Conclusion

When it comes to single-tooth implant restorations in the anterior area, the Dr Mir laser-assisted dental implant technique can be considered a convincing alternative to conventional treatment methods for achieving aesthetic results.

Acknowledgements: The author would like to thank all of his colleagues at RWTH Aachen University in Germany and especially Prof. F. Lampert, Prof. N. Gutknecht, Prof. R. Poprawe, Dr J. Meister, Dr C. Apel, Dr R. Franzen and Mr L. Vanweersch for their continuous support during his time of study at the university between 2002 and 2013.

Literature

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Dr Maziar Mir (DDS, M.Sc.) is a dentist from Iran. He obtained his DDS in Iran in 2000 and his M.Sc. at RWTH Aachen University in 2006. He completed his postdoctoral fellowship at the University of California, Irvine, in the US in 2009. In addition, he obtained his PhD from RWTH University in 2012, qualifying for habilitation. He won two prizes for his works on SWEEPS and PIPS. He currently runs a private clinic in Tehran in Iran.

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SSP/SWEEPS endodontics with the SkyPulse Er:YAG laser

Dr Tomaž Ivanušič, Slovenia

Introduction

The goal of endodontic therapy is to eliminate pathogenic substances from the root canal system. However, standard mechanical instrumentation leaves a significant portion of the complex root canal system uninstrumented. Additionally, the mechanical instrumentation itself creates a smear layer and an accumulation of debris that need to be removed as well. For this reason, an irrigation phase of the therapy is required in order to eliminate the potential pathogens, and to remove the debris resulting from the instrumentation phase of the procedure. Different methods and technologies have been introduced with the goal to improve the efficacy of the standard syringe root canal irrigation procedure. One of the most recent techniques involves SSP/SWEEPS® laser-activated irrigation (LAI) using a special type of the Er:YAG (erbium-doped yttrium aluminium garnet) laser with extremely short laser pulses, generating photon-induced photoacoustic streaming of the irrigant throughout the complex three-dimensional root canal system (Fig. 1).

The photon-induced photoacoustic streaming is achieved through the high absorption of the SSP (super-short pulse; 50 µs) Er:YAG laser pulse in the irrigant, which initiates the rapid formation of a vapor bubble at the fibre tip (FT) while it is immersed in the irrigant. Due to the very high absorption coefficient of the Er:YAG laser wavelength (λ = 2,940 nm) in irrigants, all of the laser pulse light is absorbed within the approximately 1 µm-thick fluid layer. Thus, the fluid is locally and instantly heated over the boiling point and a vapor bubble starts to form at the FT's end. After the explosive boiling, the vapor bubble starts to expand. When it reaches its maximum volume, it is nearly empty and it starts to collapse due to the pressure of the surrounding liquid. This phenomenon induces turbulent fluid movement within the whole root canal volume, significantly improving the efficacy of chemomechanical debridement. Additionally, for super-short laser pulses, the effects of thermal diffusion during bubble formation are minimal.

A unique solution for modern endodontics

The ultimate goal of SSP/SWEEPS® is to significantly enhance several irrigation mechanisms: 3D streaming of the irrigant throughout the complex root canal system; increased penetration of the irrigant deeper into the dentinal tubules; removal of debris and the smear layer from the root canal system; more effective chemical activation of NaOCl; direct (non-chemical) removal of biofilm; and direct (non-chemical) disinfection. The clinical efficacy and safety of SSP laser-activated irrigation has been extensively investigated. However, research indicates that further improvements can be achieved by tailoring the Er:YAG laser emission characteristics to the specific requirements of the above irrigation mechanism.

This has led to the development of SSP/SWEEPS® endodontics, where the extremely effective single-pulse SSP irrigation is complemented with an additional, dual-pulse SWEEPS® (shock wave enhanced emission photoacoustic streaming) technique. The SWEEPS® modality is based on the finding that, as opposed to large liquid reservoirs, shock waves, i.e. waves travelling faster than sound, are not observed in spatially confined reservoirs such as root canals. This is because in narrow canals cavitation dynamics are significantly slowed down by the friction on the canal walls and by

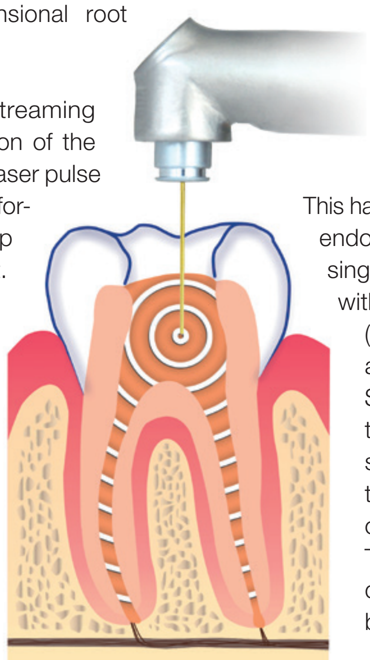

Fig. 1: Laser-activated irrigation technique using SSP/SWEEPS® Er:YAG laser technology and the photon-induced photoacoustic streaming protocol (PIPS). The laser fibre tip is placed in only the coronal portion of the pulpal chamber, and left stationary, allowing the photoacoustic waves to spread into the openings of each canal. This enables a more minimally enlarged canal preparation, and without thermal damage as is seen with techniques requiring placement into the canal system.

the limited space available for the quick displacement of the liquid during the bubble's expansion and contraction. The SWEEPS® modality consists of delivering a subsequent laser pulse into the liquid at an optimal time when the initial bubble is in the final phase of its collapse. The growth of the second bubble exerts pressure on the collapsing initial bubble, accelerating its collapse and the collapse of secondary bubbles, resulting in the emission of primary and also secondary shock waves.

Materials and methods

The Er:YAG laser (λ = 2,940 nm) used in this study was the SkyPulse (Fotona), equipped with the H14 handpiece, optically coupled with interchangeable fibre tips (Fig. 2). The handpiece air/water spray was turned off during all experiments. The following fibre tips were used in the study:

1. Cylindrical flat-ended fibre tips with diameters of 400 µm (Flat Sweeps400) 500 µm (Flat Varian500) and 600 µm (Flat Varian600);*
2. Cylindrical radially-ended (tapered) tips with diameters of 400 µm (Radial Sweeps400) and 600 µm (Radial Sweeps600). Note that the Radial Sweeps600 tip is geometrically equivalent to the standard 600 µm "PIPS" fibre tip.**
3. Conical flat-ended tips with diameters of 400 µm (Conical Sapphire 400) and 600 µm (Conical Sapphire 600).

The SkyPulse laser system was operated in the single-pulse SSP emission mode and in the dual-pulse SWEEPS® emission mode. Since the proper timing of the SWEEPS® pulse pair depends on the cavitation bubble's oscillation time, which depends on the geometry of the access chamber, the SkyPulse's SWEEPS® modality consists of automatic repetitive sweeping of the temporal separation between the SWEEPS® pulse pair back and forth within an optimal range (SWEEPS®) of temporal separations in order to ensure effective irrigation regardless of the tooth type and chamber size preparation. It is the accelerated collapse of the first bubble in the SWEEPS® pulse pair that results in the enhanced shock wave emission and improved irrigation, while the role of the second bubble is mainly to amplify the effect of the first bubble.

Measurement of root canal pressure

Measurements were performed in a simulated tooth model with the entrance diameter of the conically shaped access cavity of 3 mm, submerged 4 mm deep under the water level of a large water-filled reservoir. This provided a stable fluid pressure within the root canal in the absence of LAI, and enabled constant replenishment of irrigant. The laser fibre tip's end was positioned 2.5 mm deep into the access chamber. The average generated pressures (P_{ave}) for different irrigation protocols were calculated based on determining the pressure changes in

Fig. 2: The SkyPulse Er:YAG laser used in the study is equipped with the two latest laser-activated irrigation modalities: SSP and SWEEPS®, thus enabling a complete SSP/SWEEPS® endodontic treatment.

apical, middle and coronal part of the simulated tooth model. The SkyPulse Er:YAG laser was set to emit radiation in the single pulse SSP emission mode. For comparison, measurements with another Er:YAG laser device, LightWalker (Fotona) were also made under the same conditions and using the same handpiece (H14) and fibre tips. Both lasers were operated with the single-pulse energy of 20 mJ and a repetition rate of 15 Hz.

Measurement of debris removal rate

Cleaning efficacy was measured in a root canal model. The experimental set-up consisted of a transparent root canal model, submerged in a glass container filled with distilled water. The root canal model was filled-up with a suspension paste to simulate debris. A biological calcium hydroxide-based paste was used in the validation phase of the experiment. In the measurement phase, a gel den-

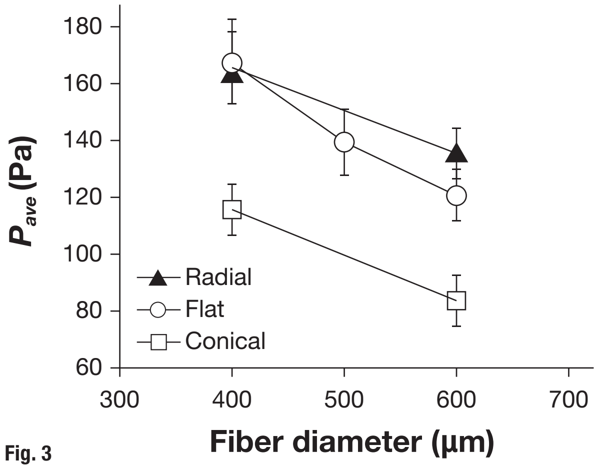

Fig. 3

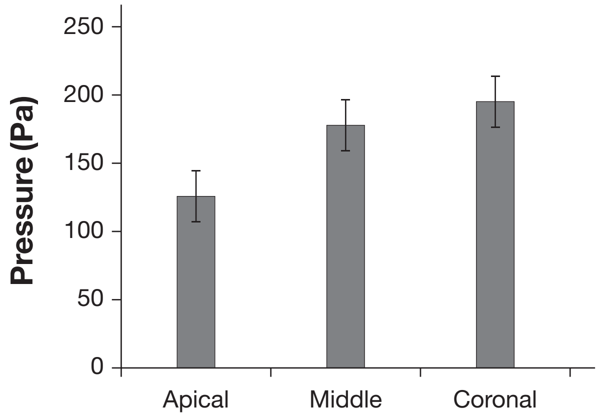

Fig. 4

Fig. 3: Dependence of pressure generation efficacy on fibre tip type and diameter. **Fig. 4:** Measured pressures at different locations within the root canal for different fibre tips. The SSP mode with pulse energy of 20 mJ and pulse repetition of 15 Hz, delivered by a SkyPulse Er:YAG laser device, was used.

tifrice was used, which yielded comparable results to the biological paste but was easier to handle and required less time to empty and refill the root canal model between measurements.

Laser pulses with a single-pulse energy of 20 mJ were delivered through the Flat Sweeps400 fibre tip positioned inside the root canal model. The images of the root canal during LAI were captured by a video camera and analysed using custom-developed software. The cleaning rate was determined from the measured reduction of the height of the simulated debris (paste) within the root canal model, with the irrigation time of 180 s. Shorter irrigation times were used for calculation when the root canal became fully cleaned, i.e. emptied of the paste, already before the expiry of 180 s. Each cleaning rate data point represents an average of at least five repeated irrigations. The cleaning rate measurements were made for the single-pulse SSP emission mode and for the automatically swept SWEEPS® emission mode.

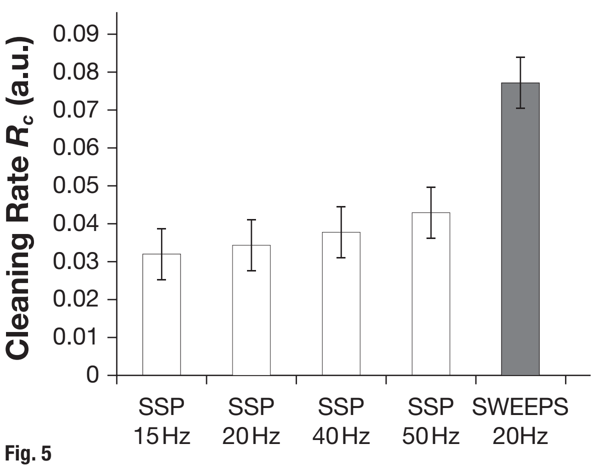

Fig. 5

Fig. 5: Debris removal (cleaning) rates R_c for the SSP and SWEEPS® emission modes with single-pulse energy of 20 mJ. The SWEEPS® mode exhibits a significantly enhanced cleaning rate.

Results

Pressure measurements

Dependence of average pressures P_{ave} (as measured for both LightWalker and SkyPulse laser devices in SSP mode) on fibre tip type (radial, flat or conical) and diameter is shown in Figure 3. Pressure measurement results show that in general the pressure generation efficacy is higher for smaller fibre tip diameters. Detailed pressure distributions within the apical, medial and coronal part of the root canal, as measured with the SkyPulse in SSP mode, are presented in Figure 4. The distribution of irrigant pressures within the root canal as shown in Figure 4 are in agreement with the reported irrigant penetration depths at different root canal areas.

Cleaning rate measurements

The measured debris removal (i.e. cleaning) rates (R_c) for the SkyPulse SSP and SWEEPS® emission modes with single-pulse energy of 20 mJ are shown in Figure 5. The SWEEPS® mode was delivered at repetition rate of 20 Hz while the SSP emission mode was tested in the range of 15–50 Hz, in order to determine whether doubling the single-pulse repetition rate of the SSP mode would yield similar results as the dual-pulse SWEEPS® mode. As can be seen from Figure 5, the debris removal rate of the dual-pulse SWEEPS® mode is significantly higher in comparison to the single-pulse SSP mode, regardless of the SSP mode's repetition rate.

Discussion

The goal of endodontic treatment is to obtain effective cleaning and decontamination of the smear layer, bacteria and their by-products within 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. The latest SSP/SWEEPS® technology greatly simplifies root canal therapy while successfully addressing all of the ultimate goals of endodontic irrigation: 3D streaming of the irrigant throughout the complex root canal system, increased penetration of the irrigant deeper into the dentinal tubules, removal of debris and smear layer from the root canal system, more effective chemical activation of NaOCl, direct (non-chemical) removal of biofilm, and direct (non-chemical) disinfection.

3D irrigant streaming

The high absorption of temporally super-short Er:YAG laser light leads to explosive boiling of the irrigant that generates oscillating vapor bubbles causing the mixing of liquid also at distant regions of the complex root canal anatomy. Observations of debris particles show that liquid vorticity effects continue long after the bubble oscillation has ended, significantly contributing to the SSP/SWEEPS® irrigation efficacy (Fig. 6). Using the SSP/SWEEPS® technique, it is now possible to effectively debride and disinfect isthmic, cul-de-sacs, lateral canals, and apical ramifications. SSP irrigation efficacy has been previously studied using a root canal model with a lateral canal (Fig. 7). The fluid motion achieved within the lateral canal during SSP activation was at a speed of 1.5 mm/s, which is sufficient for the irrigation of any lateral canal.

Penetration of irrigants into dentinal tubules

Traditional irrigation during root canal treatment with a syringe and needle is associated with only limited penetration beyond the main canal into dentinal tubules. The limitation is particularly pronounced in the apical area. The SSP/SWEEPS® activation considerably increases the efficacy of the irrigants in the apical area, as demonstrated also by the pressure measurements in this study. The pressure measurements during SSP activation show the pressures in the apical region to be significant, by a factor of only 1.6-times smaller than the pressure in the coronal region (Fig. 4). This is in agreement with a study, which compared different methods of activation of endodontic irrigants including ultrasonic, sonic and SSP, and determined that SSP activation achieved the greatest penetration depths in the middle and apical sections.

Cleaning—removal of debris and smear layer

The present study shows that the latest SWEEPS® modality significantly enhances the debris removal efficacy even in comparison to the SSP irrigation (Fig. 5). As an example, Figure 8 shows the observed difference in the efficacy of debris removal of the SSP and SWEEPS® irrigation.

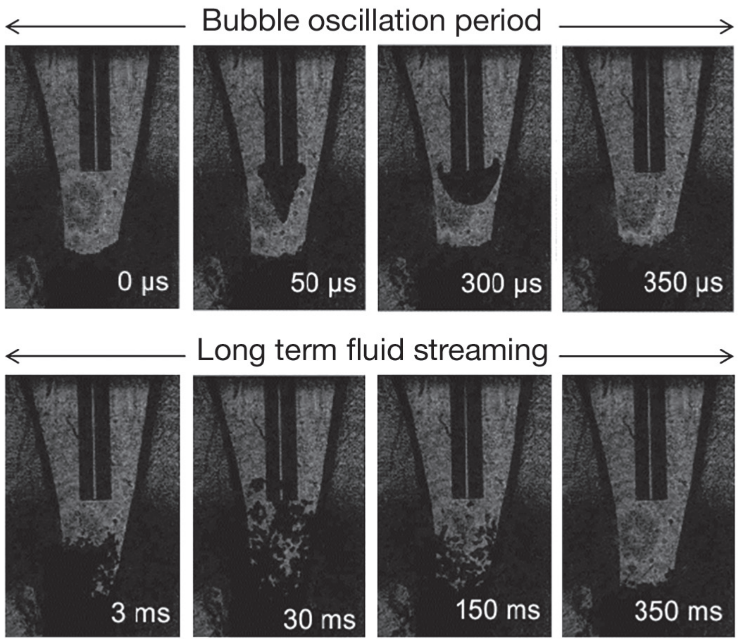

Fig. 6: The series of images shows water vorticity after a SSP laser-induced cavitation bubble using simulated debris particles. Significant water flow can be observed 2 ms after the beginning of the laser pulse, which is long after the collapse of the cavitation bubble (Tosc ≈ 300 µs). The particles settle to the ground in approximately 200 to 300 ms.

Activation, disinfection and biofilm removal

A major mechanism of action of the SSP laser-activated root canal irrigation techniques is believed to be the rapid fluid motion in the canal as a result of expansion and implosion of vapor bubbles, resulting in a more effective delivery of the irrigants throughout the complex root canal system. An additional mechanism which contributes to the efficacy of SSP is the improved removal of the smear layer, microorganisms, and biofilm as a result of the physical action of the turbulent irrigant. In addition, chemical action seems to play a role as well. For example, an increased reaction rate of NaOCl was found to occur upon activation by the pulsed erbium laser. By

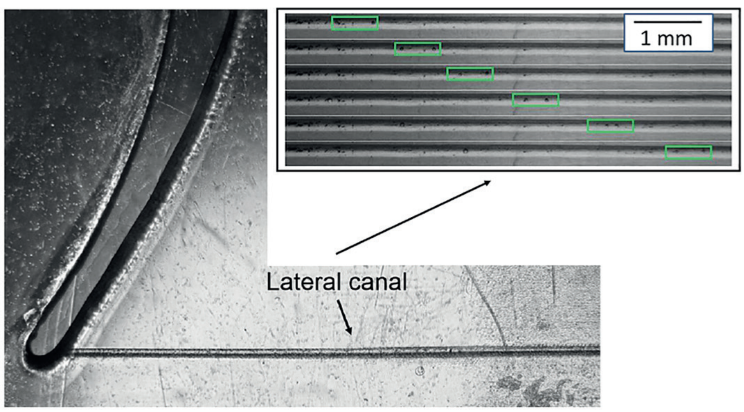

Fig. 7: Root canal model with lateral canal used in the experiment. The lateral canal was ≈ 13.5 mm long and had a diameter of 70–160 µm; observed motion of gas bubbles within the lateral canal during SSP irrigation.

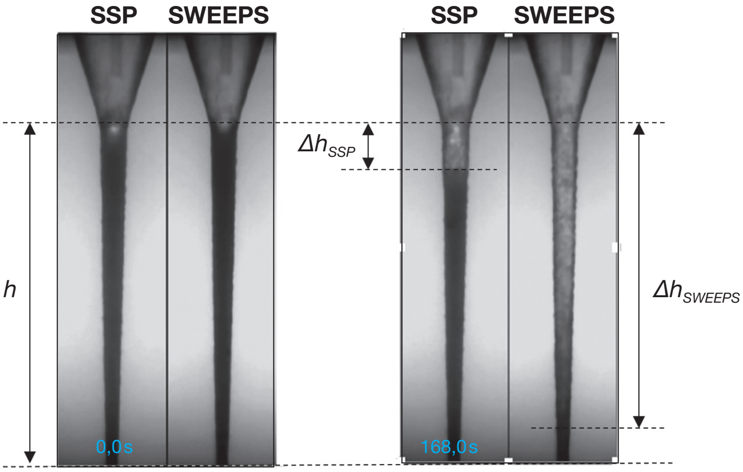

Fig. 7: Images of the filled-up root canal prior to irrigation (left) and images of the partially or fully cleaned root canal following the irrigation sequence (right). An exemplary comparison of the cleaning outcomes following irrigation with SSP and SWEEPS® emission mode is shown.

being able to generate shock waves within narrow root canals, both the physical and chemical actions of SSP can be potentially further enhanced by using the SWEEPS® technique.

Minimal risk of extrusion

It is important to note that the SSP/SWEEPS® irrigation does not result in any increase of apical irrigant extrusion. Recently, a study of the apical irrigant extrusion during SSP and SWEEPS® laser irrigation was carried out, during which irrigation using two standard endodontic irrigation needles (notched open-end and side-vented) was compared with the PIPS and SWEEPS® laser irrigation procedures. In the standard irrigation experiment, the irrigation device was a syringe coupled to either a 30G open-ended or side-vented needle, with flow rates of 1, 2, 5 and 15 mL/min. Both the PIPS and SWEEPS® irrigation procedures resulted in a significantly lower apical extrusion compared to the conventional irrigation with endodontic irrigation needles, in agreement with previous reports.

Optimal fibre tip for SSP/SWEEPS® endodontics

Pressure measurement results (Fig. 3) show that in general the pressure generation efficacy is higher for smaller fibre tip diameters. The highest efficacy was observed for the following cylindrical tips: Radial Sweeps400 and Flat Sweeps400 tips, with no significant difference between the two fibre tip types. For the larger fibre tip diameter of 600 mm, the radially-ended fibre tip was slightly more effective than the flat-ended tip. This is because radially-ended tips generate spherically shaped bubbles where opto-dynamic energy conversion efficiency is optimal, while flat-ended tips tend to generate more spheroid-shaped bubbles. This difference becomes less pronounced for smaller fibre tip diameters where bubbles become approximately spherical regardless of the fibre tip ending.

The SSP irrigation has been typically performed using the PIPS 600 mm fibre tip, geometrically equivalent to the Radial Sweeps600 tip. However, based on the results of the present study, the narrower Radial Sweeps400 fibre tip is even more effective and therefore appears to be a preferred choice. On the other hand, when fibre tip longevity is of concern, the appropriate choice is the Flat Sweeps400 tip. This tip was found to exhibit the same pressure efficacy as the radially-ended tip (Fig. 3), however, it is more durable, especially when performing SWEEPS® activation where the radial fibre tip's cone can get more readily damaged by the generated shock waves.

Conclusion

Our study indicates that the combined SSP/SWEEPS® technology of the SkyPulse Er:YAG laser system has the potential to greatly simplify root canal therapy while successfully addressing the major goals of endodontic irrigation. The ability of SSP/SWEEPS® to three-dimensionally debride and decontaminate dentinal tubules thus allows the clinician to effectively deliver treatments in less time and with less need to enlarge the canal system, allowing for a more minimally invasive preparation.

* Previous manufacturer's codes for cylindrical 400, 500 and 600 µm fibre tips were Varian400, Varian500 and Varian600, correspondingly.

** Previous manufacturer's codes for tapered cylindrical 400 and 600 µm fibre tips were XPulse400 and XPulse600, correspondingly.

Literature

about the author

Dr Tomaž Ivanušič graduated from the University of Ljubljana's Faculty of Medicine in 2017. Thereafter, he served a one-year internship, where he gained experience in different dental specialties. Primarily focussing on Endodontics, Restorative Dentistry and Laser Dentistry, Dr Ivanušič currently works as a dentist in a private clinic in Slovenia. In addition, he works as researcher, lecturer and trainer, and has been involved in the development of laser systems including the Fotona SkyPulse.

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Dr Dimitris Strakas, Greece

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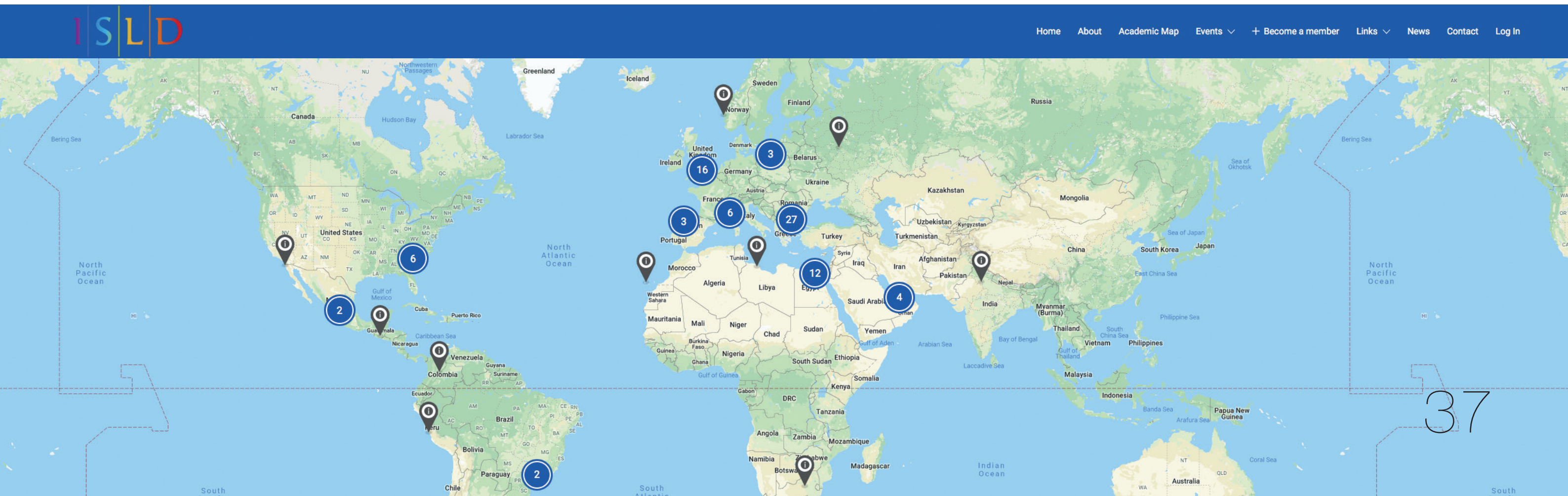

Successful communication in your daily practice

Part XI: Attracting prospective patients from abroad

Dr Anna Maria Yiannikos, Germany & Cyprus

This series covers the most common and challenging scenarios that might arise in your dental practice and presents successful ways to deal with them in order for you to enjoy greater peace of mind. Each article of this series teaches you a new, easy-to-use specialised protocol which can easily be adapted to your own dental clinic's requirements from the outset.

Today's challenging topic deals with how you can attract patients from abroad and expand your client base as a result. Personally, I find the topic of medical tourism extremely exciting. In the following article, I will provide seven essential steps towards attaining your goals. You may have tried several companies and websites already, but not had the desired return on your investment and not attracted the number of patients you had expected to. Today, I promise that, by following the seven steps below, you will attract patients from abroad at very low cost easily and effectively.

7 essential steps

1. Accredit your clinic to international standards

Patients feel more comfortable visiting a practice that has its credentials of safety and quality accredited by independent international organisations—and correctly so. Prospective patients are more likely to travel to your country and visit your practice if they are certain that they will receive proper treatment in a safe and professional practice environment. For instance, accredit your practice to international standards, such as ISO 9001 or ISO 45001. The former comprises a variety of widely accepted quality standards and the latter is the globally recognised occupational health and safety management system.

2. Use your website to clearly show that which distinguishes your practice

Prospective patients will only take note if you tell them something useful, something that not only addresses their needs but also satisfies their desires. If you are the expert, show them. You could, for instance, inform them on the benefits to themselves of your unique dental equipment, or demonstrate your difference through the processes that you and your team employ. Show them that you offer not only a treatment but also a great experience.

3. Use before and after photographs in your promotional online channels
People are usually rather cautious about spending a great deal of money travelling abroad for treatment that they do not know the outcome of beforehand. Distributing contrastive before and after photographs and making them publicly available via online promotional tools, such as Google Ads, social media, blogs or your homepage, can be a great way to assure prospective patients that you deliver on your promises with regard to treatment outcomes.

4. Highlight your credentials
Highlighting your credentials encourages patients from abroad to visit you. When they come to you, they must feel that they already know you and that you are well educated—you need to accomplish that via your online presence.

5. Make use of your media resources
Use all your promotional media resources wisely to make your clinic visible and known. Draw up a promotional plan for every month and keep to it.

6. Ask loyal patients to submit testimonials
Video testimonials or testimonials in written form from patients who have visited you before can be a vital promotional tool for you and can greatly influence prospective patients' decisions.

7. Be prompt in your response
Do not delay in answering prospective patients' e-mails. You could have set templates for different treatments that they may ask about. Consider setting up preprogrammed e-mail responses on veneers or implants in which you explain the materials that you use, the associated price and the benefits for them. This will certainly save you time.

Isn't that easy?

Use the above-mentioned steps as a protocol in your daily practice and you will soon notice an influx of new patients from abroad and—most importantly—feel in control of this new situation. You now know the exact steps required to attract and engage with patients from other countries. Moreover, I am confident that you will most likely experience an increase in income as a consequence too. Just try it and let me know what you think!

I am sure that you are looking forward to the next issue of the laser magazine, in which I will present the 12th part of this unique series on communication protocols and consider further interesting and useful topics. Are you curious about what's next? We will talk about how to retain your newly won patients from abroad and turn them into loyal advocates, who will promote your practice in their respective home countries. As you can see—we are still not done with the topic of medical tourism, as there are many more interesting aspects to explore that you, as your clinic's leader, can capitalise on. I will continue the discussion of the topic and provide five crucial points necessary to meet your goals.

Until then, remember that you are not only the dentist at your clinic but also its manager and leader. For questions and further information and guidance, don't hesitate to reach out by e-mailing me at dba@yiannikosdental.com or see our website, www.dbamastership.com. I look forward to our next step towards business growth and educational development. Let's keep in touch!

about the author

Dr Anna Maria Yiannikos (DDS, LSO, MSc, MBA) is one of the first two women worldwide to have obtained a master's degree in laser dentistry. She has owned a dental clinic for 23 years now and leads the innovative Dental Business Administration Mastership Course at RWTH Aachen University in Germany. She is an adjunct faculty member of the Aachen Center for Laser Dentistry.

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Laser-safety loupes are especially required in dentistry. Due to the optical characteristics of a loupe the protection of the eyes is notably considered. When used in laser-assisted applications, loupes allow for an increase in the power- and energy density of the laser. Within dentistry, precise laser treatments and, as a consequence, successful treatment outcomes can be achieved using loupes. The new F27 magnifying eyewear combines the already proven F22 eyewear frame and a newly developed adapter with the magnifying glass of one of the leading German manufacturers. By virtue of the large number of available laser protection filters for this spectacle frame, a suitable magnifying glass can be configured for almost every laser application. Especially in combination with the HR2.5x/340 mm binocular loupe, the F27 can cover the entire range of dental laser applications. Additionally, laservision offers magnifiers with working distances of 420 and 520 mm for many more requirements. For further information on the available shields and filters for the innovative laser safety loupes, contact LASERVISION GmbH & Co. KG—we are always at your disposal.

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“Lasers in Dentistry” offered again

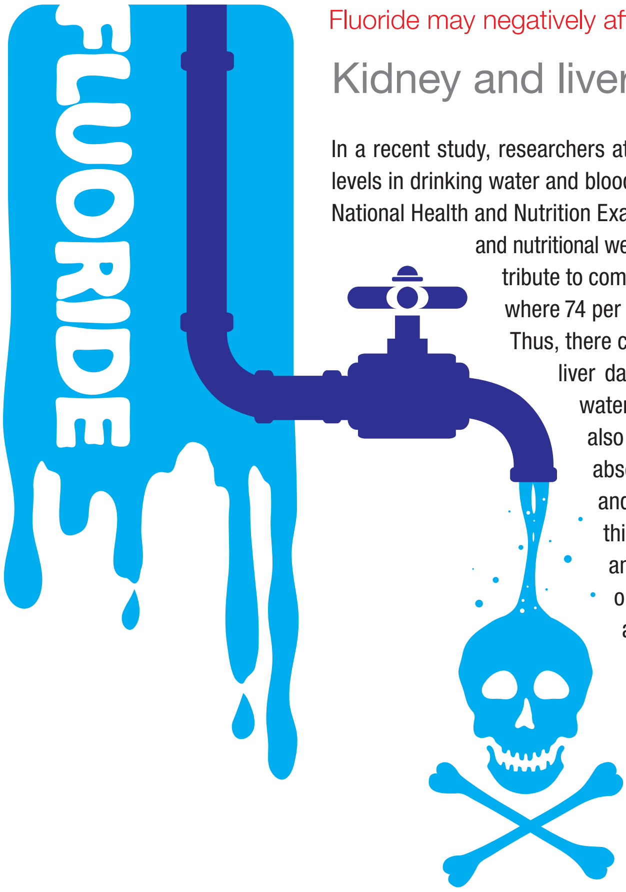
At RWTH Aachen University in 2020

In 2020 the M.Sc. programme “Lasers in Dentistry” will be offered again at RWTH Aachen University in Germany, starting on 17 September 2020. The postgraduate course is aimed at dentists looking to deliver on their patients’ wishes for innovative and gentle treatment methods. In most academic dentistry studies, dental laser technologies and laser-assisted treatment concepts are often no part of the curriculum. In this two-year Master course, however, the necessary professional knowledge for successfully integrating laser technology into the dental practice is taught at the highest academic level through theoretical lectures and practical teachings. Participants obtain an in-depth theoretical knowledge in lectures and seminars led by renowned and experienced international scientists and practitioners. Skill training sessions, exercises, practical applications, live operations and workshops guide participants towards using lasers successfully and professionally in their own oral surgeries. More information can be found online at www.aalz.de.

AALZ

Aachen Dental Laser Center

Source: AALZ



Fluoride may negatively affect

Kidney and liver function

In a recent study, researchers at Mount Sinai hospital, New York, examined the effect of fluoride levels in drinking water and blood on the kidney and liver health of adolescents participating in the National Health and Nutrition Examination Survey (NHANES), a group of studies that assess health and nutritional well-being in the USA. It was shown that exposure to fluoride may contribute to complex changes in kidney and liver function among youth in the USA, where 74 per cent of public water systems add fluoride for dental health benefits. Thus, there can be potential health side effects, such as renal system damage, liver damage, thyroid dysfunction, bone and tooth disease. Fluoridated water is the main source of fluoride exposure in the USA. The findings also suggest that adolescents with poorer kidney or liver function may absorb more fluoride into their bodies. Fluoride exposure in animals and adults has been associated with kidney and liver toxicity, and this study examined potential effects of chronic low-level exposure among youth. This is important because a child’s body excretes only 45 per cent of fluoride in urine via the kidneys, whereas an adult’s body clears it at a rate of 60 per cent. Moreover, the kidneys accumulate more fluoride than any other organ in the body. The study, titled “Fluoride exposure and kidney and liver function among adolescents in the United States: NHANES, 2013–2016”, was published in August 2019 in *Environment International*.

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