

The treatment approach to caries using the Er:YAG laser

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Biological chromophores

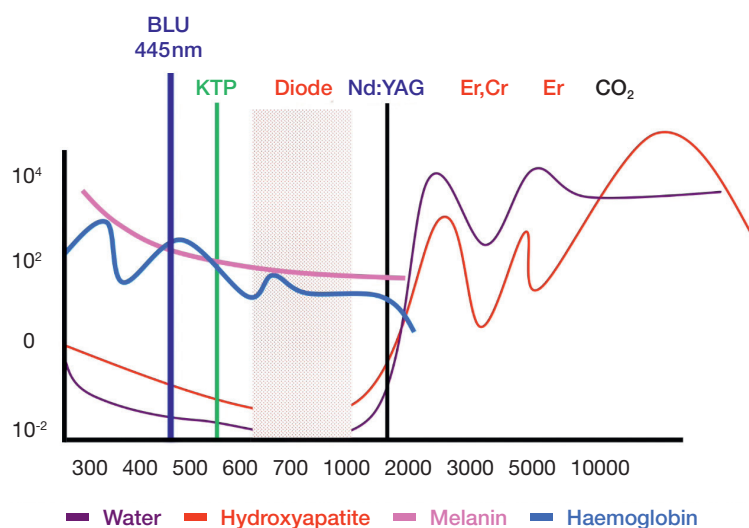


Fig. 1: The absorption of the 2,940nm wavelength by water and hydroxyapatite.

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 amorphous 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

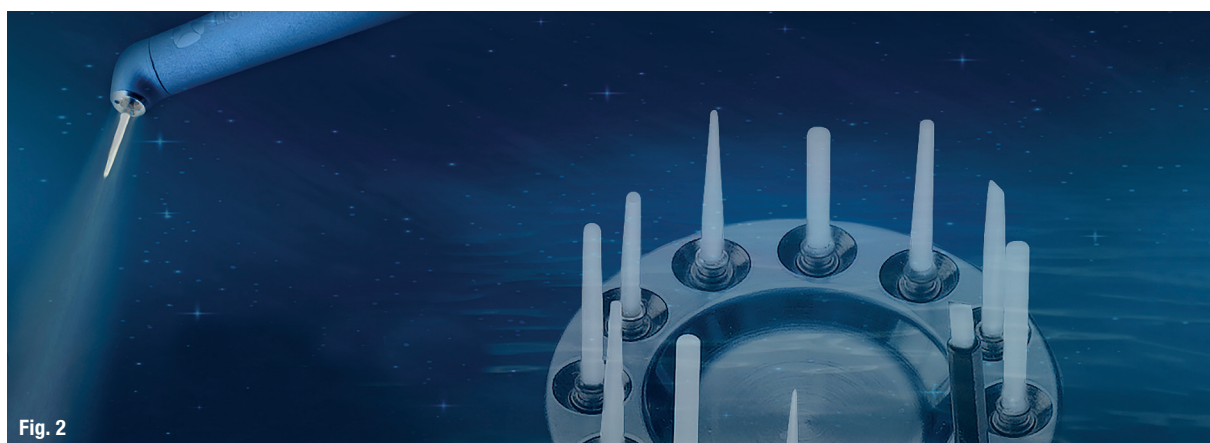


Fig. 2

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 2,940nm 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 2,940nm 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.

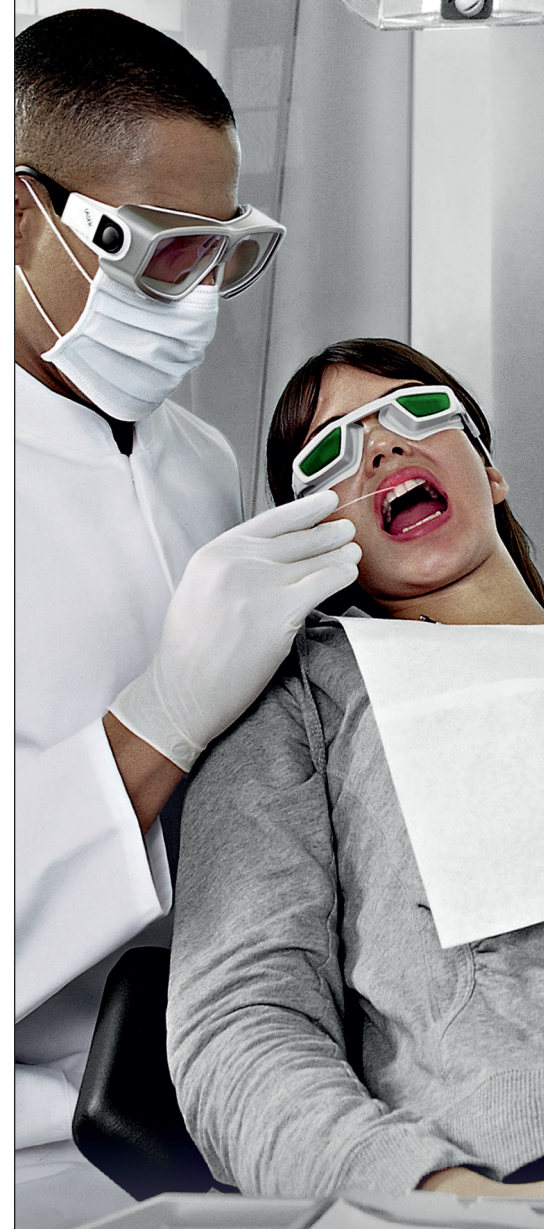
Caries treatment with Er:YAG laser fulfills many of the requirements of MID: the ability to ablate small areas of the infected layer guarantees maximum conservation of the tooth structure; the diameter of the Er:YAG laser in contact mode delimits an ablation area of 0.8–1.3mm in diameter (in fact the ablation area may be even smaller; Fig. 2) so that irradiating dental hard tissue with laser allows ablation of areas no larger than 0.8mm 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 amorphous 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 amorphous dentine

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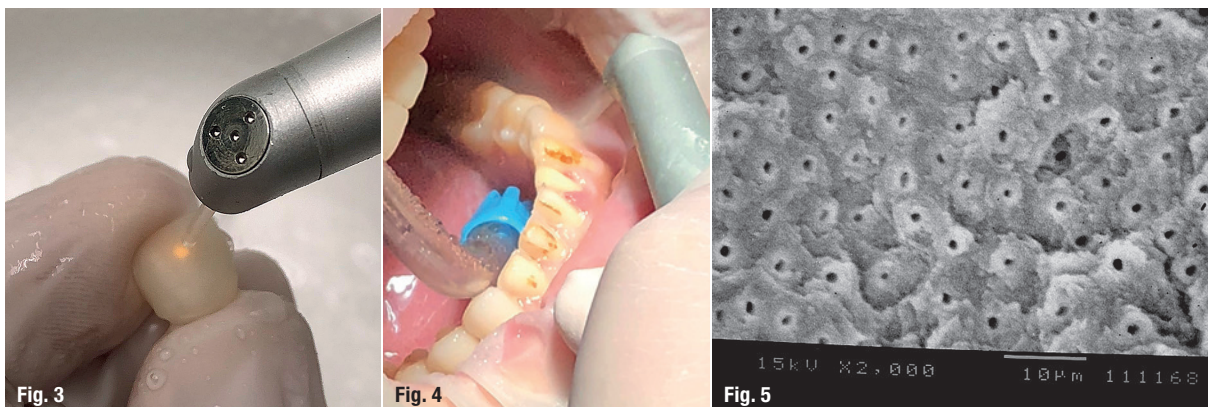


Fig. 3: Irradiating dental hard tissue with a laser tip of 1.3 mm allows ablation of areas no larger than 1.3 mm. **Fig. 4:** Good visual control of the ablation procedure contact-free. **Fig. 5:** The dentinal surface under SEM after Er:YAG laser irradiation: surface without a smear layer and with open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

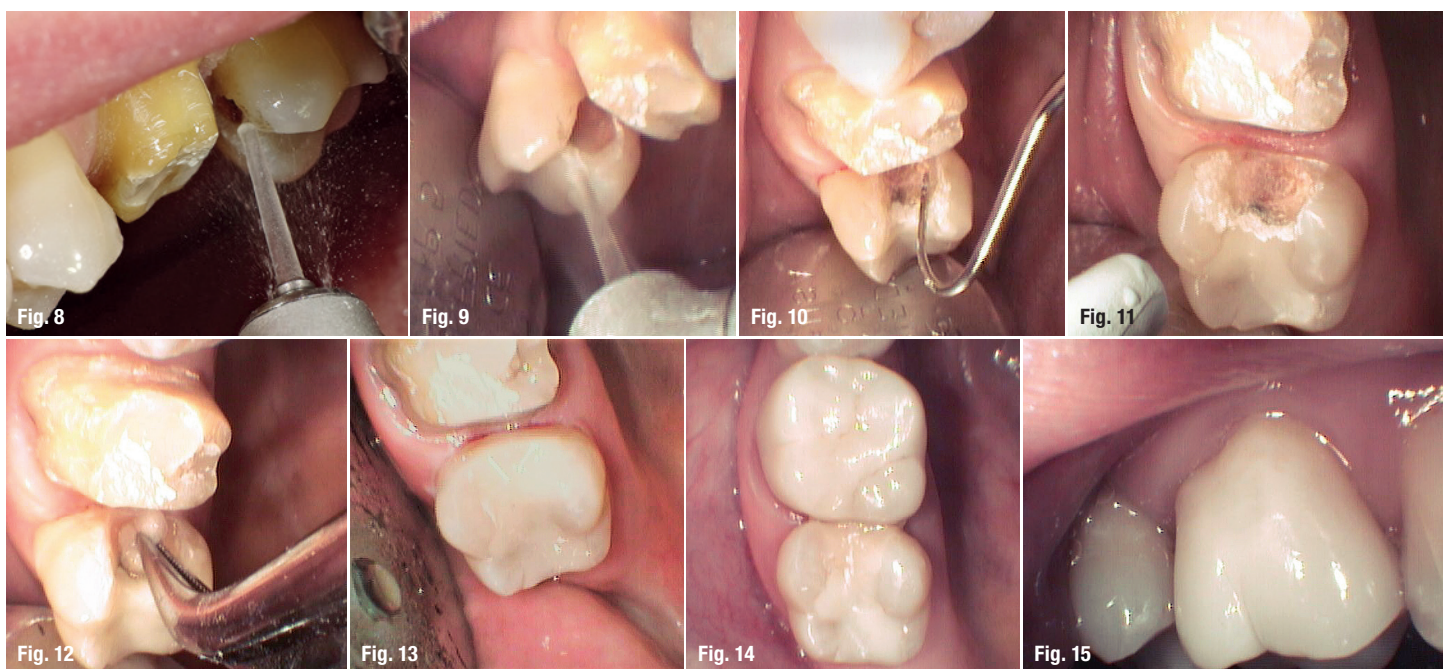
The introduction of resin-based composite restorative materials in dentistry aided the pursuit of the goals of MID. Conditioning the dentinal surface removes the smear layer and opens the dentinal tubules after bur preparation, forming a defined hybrid layer and resin tags of the composite material in 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.



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 14.0mm in length and 1.3mm in diameter by inserting the tip inside the cavity at a distance of about 2mm from the carious tissue. **Fig. 10:** Checking progress of removal of the amorphous 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 4.0mm in length (magnum) and 1.3mm in diameter at a distance of 10mm from the tooth surface in a non-contact mode with energy of 300mJ and 20Hz, 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 14.0mm in length and 1.3mm in diameter, inserting the extremity of the tip inside the cavity at a distance of about 2mm 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 1.3mm 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

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