

# Minimally invasive dentistry (MID) concepts for the caries treatment by Er:YAG laser

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## Introduction

The dental caries lesion is a bacterial infection created by cariogenic bacteria resulting in increased proportions of acid, producing consequently a low pH that produce a demineralization of the tooth structure.<sup>1,2</sup> In the past, carious treatment approach was mainly a surgical removal of the infected tissue and the subsequent tooth reconstruction with a dental restorative material. At that time, diagnosis of caries lesions was carried out at more advanced disease stages than the incipient lesions detected today and instrumentation was limited to slow rotary and hand instruments.

The cavity preparation had an excessive tooth structure reduction even for relatively small lesions, removing not only the caries tissue but also healthy integrate tooth tissue in order to follow the concepts of extension for prevention, resistance and retention.<sup>3,4</sup>

The modern operative dentistry is moving to a minimally invasive approach, in which caries are managed as an infectious disease and the focus is on

maximum preservation of tooth structures.<sup>5,6</sup> The introduction of adhesive dental materials made it possible to conserve tooth structure using, minimal invasive preparation, because adhesive materials don't require any incorporation of mechanical retention features. Minimally invasive dentistry (MID) adopts a philosophy that integrates prevention, remineralization and minimal intervention for the placement and replacement of restoration. MID reaches the treatment objective using the least invasive surgical approach with the removal of minimal amount of health tissue.<sup>7</sup>

Nowadays the erbium laser can be the answer to the MID requirements. The wavelength of Er:YAG laser is 2,940 nm that correspond to the absorption peak of water is indicated for hard dental tissue and bone ablation where the main substances are water and hydroxyapatite. Maximum absorption in water results in an effective microexplosion mechanism. The explosive vaporization creates a plume of ablation of the carious tissues. The ablative action is also due to a combination of photothermal and photoacoustic effect caused by the microexplosions of water on the target tissue.



The purpose of this clinical article is to show through out clinical cases the capacity of an Er:YAG laser (FOTONA—Slovenia) to remove caries tissue, following the concept of MID .

### Clinical cases

Caries with a depth from just in dentine to half-way of the dentine thickness (at least 1 mm away from the pulp chamber) were treated, following the requirements of MID in operative dentistry. The parameters used were: VSP mode (140 s per pulse), Energy from 150 mJ to 200 mJ, frequency from 15 Hz to 20 Hz, fluence from 30 to 40 J/cm<sup>2</sup>. Both eyes of patient's and operator's were protected by laser safety eyewear (UNIVET, 705.00.00.00.BL, certificated CE, Dir. 89/686/CEE).

The caries were ablated in focus mode using the Er:YAG laser with the mirror handpiece R2 at a distance between 0.8 to 1 cm from the tooth with slow fluid continuous movements, under water-cooling using tap water and the high speed suction to handling the plume of the carious tissues. The preparation of the cavities was limited to vaporizing of the infected layer leaving the affected one, without any ablation of healthy tooth structure.

The removing of the amorphous dentine was checked with the probe and in some cases we finished to remove the infected layer using a dental excavator (ASA stainless 1700-2).

All the teeth were restored in the same appointment using acid etch Scotchbond Etchant (3M ESPE, Dental Products), adhesive Scotchbond 1 XT (3M ESPE, Dental Products) and composite Z100 MP RESTORATIVE (3M ESPE, Dental Products).

The resin composite was polymerized in a conventional mode with a commercial halogen light 52 W, spectrum 400–515 nm (Polylight 3 Steril, CASTELLINI), curing for 40 seconds each layer of the resin composite (at least two layers for filling) with the light tip at 8 mm distance from the tooth surface.

### Case 1

Thirty years old male with occlusal dental caries (I class of Black) of the lower right second molar (Fig. 1). The treatment was done without anesthetic, using a rubber dam. The non sustained enamel and carious tissues were removed by Er:YAG laser following the modality and the parameters described above (Figs. 2 & 3). The cavity was filled with composite resin as describe above (Fig. 4).

### Case 2

Forty two years old female with mesio-occlusal dental caries (II class of Black) of the upper left first molar (Fig. 5). The treatment was done without anesthetic, using a rubber dam. The non sustained enamel and carious tissues were removed by Er:YAG laser following the modality and the parameters described (Figs. 6 & 7). The treatment was completed with a composite restoration (Fig. 8).

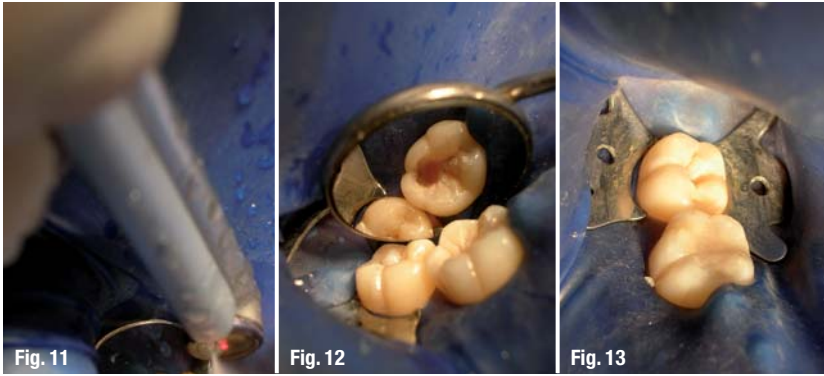
### Case 3

Twenty nine years old female with occlusal dental caries (I class of Black) of the lower right first molar (Fig. 9). The treatment was performed under a rubber dam using the Erbium to remove the carious tissue (Fig. 10). During the application was not necessary to use anesthetic. The non sustained enamel and carious tissues were removed by Er:YAG laser following the modality and the parameters described in the general part (Figs. 11 & 12). The cavity was filled with composite resin (Fig. 13).

### Discussion and conclusions

The modern operative dentistry can be based on a minimally invasive techniques where caries removal and cavity preparation can be completed with minimal tissue removal. The conservation of hard dental tissue increases the longevity of the restored tooth.<sup>8</sup> The use of Er:YAG laser is efficient, effective, safe and suitable for caries removal and cavity preparation<sup>9,10</sup>, generating similar heat increases under water-cool-





ing compared to the preparation with high-speed instrument.<sup>11,12</sup>

The aiming beam of Er:YAG laser (incorporated in the system) delimit an ablating spot area of 0.8 mm diameter (in fact the ablating area is even smaller) so that irradiating dental hard tissue with laser in focal mode allows to ablate areas not larger than 0.8 mm in diameter.<sup>13</sup>

Removing only small areas of dental caries can't be done with the conventional burs because even the smallest one, when drilling, takes off more tissue. Additionally the burs are removing tissue tridimensionally comparing to the laser beam that is vaporizing just the irradiated surface. Having the possibility to ablate with Er:YAG laser small areas helps in reaching one of the most important goal of MID that is the maximum preservation of dental tissue. The MID divided the carie lesion in two layers. The infected layer which is heavily bacteria contaminated is composed of soft amorphous dentin (denatured collagen matrix) without any potential ability to remineralize. The underlying layer, the affected one that is less contaminated by bacteria, is partially demineralized with an intact collagen matrix conserving the potential to remineralize. The goal of MID is to eliminate the infected layer of the caries conserving the below affected layer.<sup>14</sup>

The diamond and tungsten carbamide burs are indiscriminant in their removal of carious tissue, usually removing infected and affected dentin simultaneously without the possibility to distinguish between the two zones, sometime even extending into underlying intact dentin. Using the Er:YAG laser beam for caries removal the visual control of the ablating area is better than with the conventional instruments and having the possibility to vaporize such small areas of 0.8 mm diameter, it is possible to vaporize only infected tissue and to stop the moment the affected zone is reached as suggested by MID.

The bactericidal effect of laser system on dentin surface was demonstrated in a several studies. The

good disinfection of the contaminated dentin prevents failure of the restoration process (secondary caries).<sup>15,16</sup> Decontaminating the affected layer after removing the soft amorphous dentine can help in preventing possible future pulp complications.

The introduction of resin-based composite restoration in dentistry helped to reach the goals of MID. Conditioning the dentine surface removes the smear layer and opens the dentine tubules, after bur preparation, forming a defined hybrid layer and resin tags of the composite material into the opened tubules. The ablation of dental hard tissue with Er:YAG laser leaves dentin surface without smear layer (unlike after bur preparation) The lack of smear layer allows the formation of hybrid layer and resin tag hybridization into the opened dentin tubules resulting in a better retention of the adhesive composites. Additionally some studies showed an enlargement of dentin tubules.<sup>17</sup>

The irradiated enamel at SEM have the characteristic appearance of a lava flow.<sup>18,19</sup> This appearance is due to the complete opening of the prism core with a partial ablation of the interprismatic structure. The irregular aspect of the peripheral enamel is due to the fragility of the hexagonal form of the prisms that looks "ready to break". The irregularity of the enamel surface after Er:YAG laser irradiation can be compensated with the application of phosphoric acid that attacks and regularize the previously opened prisms; by this way the enamel surface increases the micro-infiltration of the bonding. It is important to remember that using an adhesive system after laser preparation of the tooth, the enamel surface prepared by laser should be follow by acid etching to allow less microleakage at the interface enamel-composite, however, this has no influence regarding bond strength and/or shear bond strength values.<sup>20,21</sup>

The conclusion of this clinical experience is that the Er:YAG laser is a valid option in the removal of dental caries respecting the concepts of minimally invasive dentistry.

*Editorial note: The literature list can be requested from the editorial office.*

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