# Er:YAG laser and composite resin ablation

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[PICTURE: ©STASIQUE]

## _Introduction

In 1954, Buonocore[1] initiated a real revolution in dentistry by proposing the possibility of obtaining stronger adhesion between composite resin and enamel through an etching process using orthophosphoric acid. The practical application of his theory completely changed the rules of conservative dentistry, shifting from the concept of "extension for prevention"[2] to that of "minimally invasive dentistry"[3] and, subsequently it was applied, with several advantages, also in orthodontics[4] and pediatric dentistry.[5] Although such adhesive systems are largely employed in dentistry today, there are still some unsolved problems.

In fact, the etch depth is variable and not predictable[6], as well as the type of acid-etching pattern according to the Silverstone classification[7,8]; moreover, rinsing does not necessarily completely arrest the acid etching process in the depth of the exposed enamel[9] and, last but not least, there is a clinical challenge in controlling the geometry and extent of the etched enamel area.[10]

With the aim to eliminate these disadvantages, several methods were proposed over the years as an alternative to orthophosphoric acid, such air abrasion and maleic acid[11-13], but the results were not encouraging. In 1990 Hibst and Keller[14] described the possibility of using the Er:YAG laser for cavity preparation in conservative dentistry.

This wavelength (2,940 nm), being very close to the absorption peaks of water (3,000 nm) and hydroxyapatite (2,800 nm), which are largely present in enamel and dentine, causes the explosion of the intracellular water and thus the destruction of the dental tissues (15).

In recent years many advantages of using laser technology, as compared to the traditional rotating










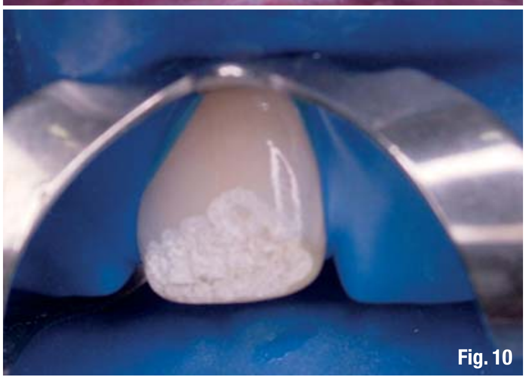


**Fig. 1**_Case 1, initial situation.
**Fig. 2**_Extensive resorption of the root.
**Fig. 3**_After laser application.
**Fig. 4**_Application of orthophosphoric acid.
**Figs. 5 & 6**_Application of composite resin, polymerisation and polish.
**Fig. 7**_Case 2, initial situation.
**Fig. 8**_Bleaching.
**Fig. 9**_Post-treatment results.
**Fig. 10**_Laser application.

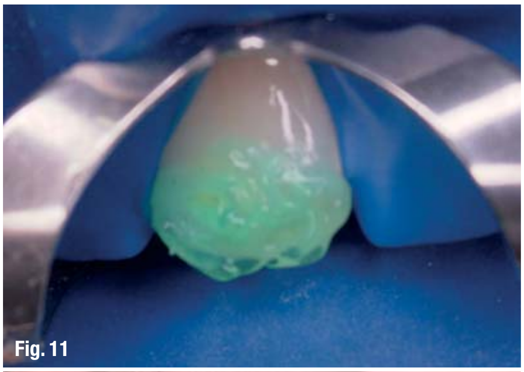
Fig. 11


Fig. 12


Fig. 13


Fig. 14

**Fig. 11**_Application of orthophosphoric acid.
**Fig. 12**_Application of composite resin, polymerisation and polish.
**Fig. 13**_Case 3, initial situation.
**Fig. 14**_Removal of amalgams, preparation of the cavities.

instruments, have been described and demonstrated by *in vitro, ex vivo* and *in vivo* tests.[16-19]

An interesting study, based on a questionnaire given to 100 patients, recorded the patients' satisfaction after receiving conservative dental treatments by Er:YAG laser: all the patients reported that they wished to be treated only by laser in the future, and they also wanted to suggest this opportunity to their friends.[20]

One controversial aspect regards the need to use orthophosphoric acid also after Er:YAG laser preparation. The most validated theory is that to obtain the maximum bond strength and the minimum of microleakage, it is necessary to also perform a conventional etching after laser conditioning.[21]

Recently, a great deal of importance has been given to the mode of the irradiation, in particular to the pulse duration: an interesting *in vitro* study[22] based on strength analysis by traction test and morphological analysis by SEM and Atomic Force Microscope, showed the same effects with Er:YAG irradiation alone as with acid etching. This was obtained by using the so-called "QSP" mode (Fotona, Ljubljana, Slovenia) in which each pulse is split into several shorter pulses that follow each other at an optimally fast rate. In this way, a specific surface roughness is achieved, representing a real alternative to acid etching. Water and hydroxyapatite are not the only elements with which the Er:YAG laser has a high affinity—its interactions with PMMA and Silicon Dioxide are also very interesting due to the fact that these two molecules are present in great concentrations in composite resin.

This, from a clinical point of view, makes the Er:YAG laser very effective in the removal of old composite restorations, with the result of obtaining a rough surface, able to be bonded to a new coat of resin, which is not possible to achieve with conventional rotating instruments.[23-24]

## _Clinical cases

*Case 1*

Patient DK, a 24-year-old woman, came to our clinic to improve the aesthetic aspect of her upper left central incisor, which had been treated many years earlier with an extensive re-construction using composite resin (Fig. 1).

The patient reported that during a road accident twelve years earlier, she experienced a traumatic self-extraction of the tooth, which was re-implanted after a root-canal therapy. At the X-ray examination, extensive resorption of the root was noticed, which did not allow the preparation of a crown (Fig. 2).

The superficial coats of resin of tooth 21, and also of 11 in its distal portion, were removed by Er:YAG laser (LightWalker AT, Fotona, Slovenia) with these parameters: 250 mJ, 10 Hz, SSP mode, non-contact handpiece, air-water spray. The duration of the operation was around seven minutes. No anesthetics were used and the patient reported no pain or dis-


Fig. 15

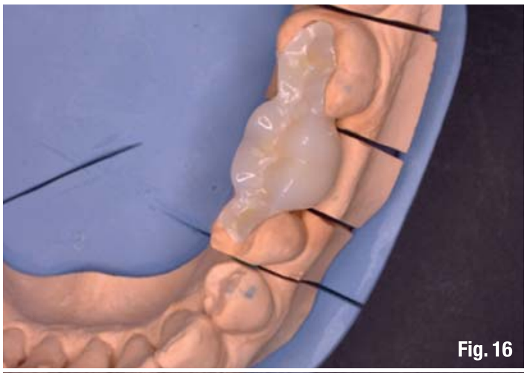
Fig. 16


Fig. 17

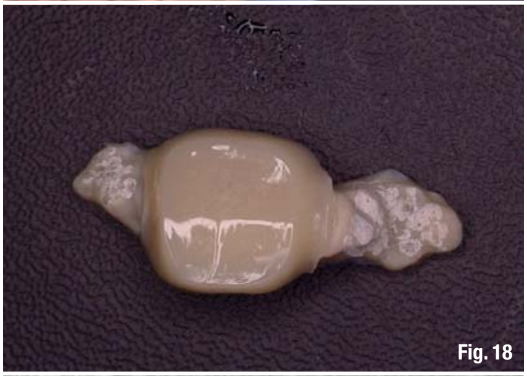
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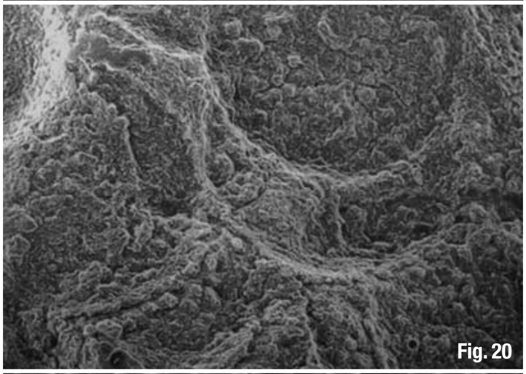
Fig. 19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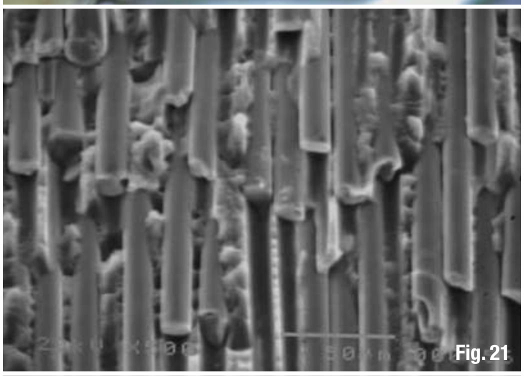
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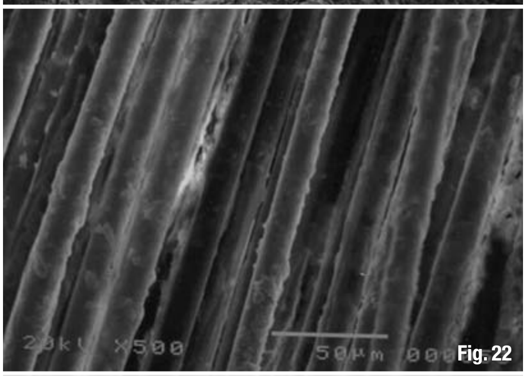
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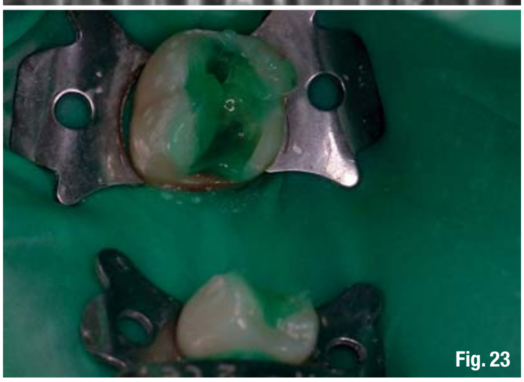
Fig. 23


Fig. 24

**Fig. 15**_Laser application.
**Figs. 16 & 17**_Same procedure on the internal surfaces of the bridge.
**Figs. 18-22**_Results of laser application.
**Fig. 23**_Application of orthophosphoric acid.
**Fig. 24**_Application of composite resin, positioning of the bridge, polymerisation.


Fig. 25


Fig. 26


Fig. 27


Fig. 28

**Fig. 25**_Application of composite resin, positioning of the bridge, polymerisation.
**Fig. 26**_Case 4, initial situation.
**Fig. 27**_Planning of a composite "Maryland bridge".
**Fig. 28**_Laser application.

comfort (Fig. 3). A gel of 37 % orthophosphoric acid was subsequently applied on the treated surface for 15 minutes (Fig. 4).

The area was rinsed, dried and a coat of bonding was applied and polymerized by LED lamp. Subsequently, a coat of composite resin was applied, polymerized and polished (Figs. 5–6).

*Case 2*

Patient PG, a 21-year-old female, came to our clinic for a bleaching treatment in the dental arches (Fig. 7). A bleaching gel containing 35 % hydrogen peroxide and a red coloring agent was used for the treatment (Fig. 8). The bleaching reaction was accelerated by Nd:YAG laser (Fidelis Plus III, Fotona, Slovenia). The patient had been previously informed that due to the fact that the bleaching agent is active only in the enamel and not in the composite, the post-treatment results would leave a chromatic difference between the two parts of the crown (Fig. 9).

To solve this problem, the superficial coat on the distal part of the upper right central incisor was ablated by Er:YAG laser (Fidelis Plus III, Fotona, Slovenia) with the following parameters: 250 mJ, 10 Hz, SSP mode, non-contact handpiece, air-water spray (Fig. 10).

The duration of the operation was around 140 sec. No anaesthetic was used and the patient reported no pain or discomfort. A gel of 37 % orthophosphoric acid was then applied to the treated surface for 15 minutes (Fig. 11).

The area was rinsed, dried and a coat of bonding was then applied and polymerized by LED lamp. Subsequently, a coat of composite resin was applied, polymerized and polished (Fig. 12).

*Case 3*

Patient LC, a 37-year old male, came to our clinic because of a missing first lower molar. Due to the presence of large, old amalgam restorations in the nearby teeth (45 and 47) it was decided to remove these old fillings and to apply a "California bridge" bonded with composite resin (Fig. 13).

The removal of the amalgams and the preparation of the cavities was performed by conventional rotating instruments and carbide burs (Fig. 14); then the impression was taken to construct the bridge. Before cementation, in order to enhance the adhesion, an Er:YAG laser (Fidelis Plus III, Fotona, Slovenia) was used for the enamel conditioning with the following parameters: 150 mJ, 10 Hz, SSP mode, non-contact handpiece, air-water spray (Fig. 15).

The duration of the operation was around 70 seconds. No anaesthetic was used and the patient reported no pain or discomfort. The same treatment, with the same parameters, was performed on the internal surfaces of the bridge, completed in composite resins reinforced with glass fibers (Targis-Vectris, Ivoclar Italia, Italy, Figs. 16 & 17).

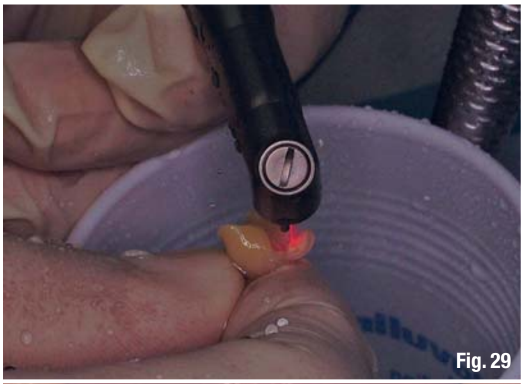
Fig. 29


Fig. 30


Fig. 31

**Fig. 29**_Laser application.
**Figs. 30 & 31**_Application of composite resin, positioning of the bridge, polymerisation.

Optical microscope observation showed that, in addition to the creation of a rough surface in the composite, the action of the laser also removed the resin around the fibers, thus allowing for penetration of the bonding agent, with a resulting stronger adhesion (Figs. 18–22). Subsequently, a 37% orthophosphoric acid gel was applied on the treated surfaces of the teeth for 15 minutes (Fig. 23). The surfaces were rinsed, dried and a coat of bonding was applied and polymerized by LED lamp. Subsequently, a coat of composite resin was applied and the bridge positioned and polymerized (Figs. 24–25).

*Case 4*
Patient MP, a 42-year-old female, came to our clinic for a rehabilitation of the left upper arch, where the first premolar was missing (Fig. 26). Due to financial considerations, it was decided to apply a composite "Maryland bridge" bonded to the nearby teeth (teeth 13 and 15, Fig. 27).

Before cementation, to enhance the adhesion, the surfaces of the teeth and the bridge were irradiated by Er:YAG laser (LightWalker AT, Fotona, Slovenia) with the following parameters: 150 mJ, 10 Hz, SSP mode, non-contact handpiece, air-water spray (Figs. 28–29).

The surfaces were rinsed, dried and a coat of bonding was applied and polymerized by LED lamp. Subsequently, a coat of composite resin was applied, the bridge positioned and polymerized (Figs. 30–31).

## _Conclusion

Since its introduction in dentistry, the Er:YAG laser has demonstrated its ability to treat an ever wider range of clinical situations with significant advantages in term of results, patient satisfaction and comfort.

Today, thanks to its efficacy in composite resin ablation, it is also possible to apply this technology to re-make old composite restorations with sound aesthetics results, and to enhance the adhesion of non-metallic prosthetics with good results in term of bond strength._

*Editorial note: A list of references is available from the publisher.*

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