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## Erbium-Doped, Yttrium-Aluminum-Garnet Laser Debonding of Porcelain Laminate Veneers: An *Ex vivo* Study

### Abstract

**Background:** The use of ceramic laminate veneer has considerably and successfully grown to improve anterior tooth esthetics in recent years. The removal of ceramic laminate veneers with laser is reported only in a scanty number of publications and for this reason the importance and the aim of this *ex vivo* study consist to verify the ability of Er: YAG laser for laminate veneers debonding with the preserving of the tooth structures (scanning electron microscopy [SEM] observations). **Aim:** The purpose of this study consists to verify if erbium-doped, yttrium-aluminum-garnet (Er:YAG) laser, at low fluences, is able to debond porcelain veneers, successfully used to improve anterior tooth esthetics, without damaging the tooth structures. **Settings and Design:** A total of 12 freshly extracted teeth were used, and samples were decontaminated, stored, and bonded to obtain veneers adhesion. One week after, Er:YAG laser with a non-contact sapphire tip with air-water spray was used for veneer debonding at 100 mJ of energy and 30 Hz of frequency (Fluence 19.94 J/cm<sup>2</sup>). **Results:** Results demonstrated that veneer debonding is possible with an Er:YAG laser and the total number of pulses seems not related to its efficiency. SEM observation confirms that residual tooth structure is not altered when using these low fluences. **Conclusions:** Low fluences with Er:YAG laser are able to debond veneers while preserving the tooth structures and SEM observation confirmed that residual tooth structure is not altered with low fluences.

**Keywords:** Debonding, erbium-doped, yttrium-aluminum-garnet laser, laminate veneer, scanning electron microscopy

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### Introduction

The use of ceramic laminate veneer has considerably and successfully grown to improve anterior tooth esthetics in recent years.<sup>[1,2]</sup> The interest of these restorations is attributable to their conservative preparation, esthetic quality, discoloration (resin cements), fracture resistance, tissue acceptance, low debonding rate, and negligible incidence of caries.<sup>[3]</sup>

The long-term success of these kinds of restoration seems to be in function of an adhesive cementation, and for this purpose, several methods for crown and teeth preparation have been proposed including computer-aided design/computer-aided manufacturing.<sup>[4]</sup>

As such all dental restorations, ceramic veneers have a limited lifespan and may ultimately need replacing at variable intervals.<sup>[5]</sup> The successful debonding process relies on maintaining the enamel structure without producing iatrogenic

damage, so allowing the enamel surface restoration, as closely as possible.<sup>[6,7]</sup>

In addition, replacement of failed restorations may be time-consuming, also compromising the additional tooth structure.<sup>[8]</sup> Bishara *et al.* demonstrated that the excessive debonding strength may cause enamel cracks.<sup>[9]</sup>

To reduce the irreversible enamel surface damage, several methods of ceramic veneers debonding have been suggested. Vertical and horizontal grooves are achievable using a tapered diamond bur, and the ceramic fragments are removable with a flat plastic or an ultrasonic instrument.<sup>[10]</sup>

Moreover, advancements and improvements in laser technology have led to multiple dental applications, such as in orthodontics.<sup>[11-13]</sup> One of these lasers, erbium-doped, yttrium-aluminum-garnet (Er:YAG), has been successfully used for debonding ceramic brackets.

The removal of ceramic laminate veneers

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with laser is reported only in a scanty number of publication, and for this reason, the importance and the aim of this *ex vivo* study consist to verify the ability of Er:YAG laser for laminate veneers debonding together with the possibility to preserve tooth structures (scanning electron microscopy [SEM] observations).

## Methods

A total of 12 freshly extracted teeth for periodontal reasons were used in this study.

Patients were informed about the inclusion of their extracted teeth in a clinical study, and their consent was registered, according to the Local Ethics Committee.

Samples (5 maxillary and 7 mandibular premolars) were extracted in the same day and immediately decontaminated and stored in a 0.1% thymol solution for 2 days. They were then rinsed for more than 1 h on coolant water and crowns were then prepared as follows:

- Enamel preparation: Vestibular enamel surfaces were prepared under air/water spray with a turbine (Kavo Supertorque 660 B, Germany) with diamond burs (Dental Diamond bur, Mani Dia Burs, TR26, 26F Japan) and polished with TR26EF burs
- Impression: Once the macroscopic evaluation of the preparation was recognized as acceptable, impressions were realized in the laboratory (Polysiloxane duplication material, Correcsil, Yamahachi Dental MFG, Co, Japan) and then porcelain veneers were realized according to the manufacturer's instructions (powder Duceram Kiss, USA)
- Sealing: For the sealing procedure, we used Universal adhesive (Single bond 3M, Espe, USA) and Veneer cement (RelyX Veneer 3M Espe, USA). After the realization of the veneers, their thickness was checked at three locations (incisal edge, middle third, and cervical third).

Teeth were then kept in closed Eppendorf tubes for 1 week on a humid atmosphere. One week after, a 2940 nm Er:YAG laser (Lite Touch, Syneron, Israel) with a sapphire tip (diameter 0.8 mm and length 14 mm) in a non-contact mode (working distance of 1–2 mm) with an abundant air-water spray (4/4 ratio) and a pulse duration of 800  $\mu$ s was used for veneer debonding. The tips were moved in a scanning mode on the whole surface of the veneers, horizontally, and vertically.

Settings of 100 mJ and 30 Hz were chosen corresponding to a theoretical fluence of 19.94 J/cm<sup>2</sup>. The total number of pulses was recorded at the beginning and the end of the irradiation, and by their difference, the pulses necessary to take off the veneer were calculated. A mean range plus a standard deviation was calculated (12 samples) [Table 1].

Once samples have been removed, coronal surfaces and ceramic laminate veneers were coated with a thin film of gold (Au) in a vacuum evaporator (Ion Sputter,

**Table 1: Number of pulses and total working time(s) to remove every veneer, mean and standard deviation**

Sample	Number of pulses
1	4077
2	10,417
3	6431
4	14,938
5	10,389
6	17,157
7	6717
8	6672
9	16,635
10	11,902
11	5052
12	7648
Mean	9836.25
SD	4501.91

SD: Standard deviation

JEOL, Japan) and observed under a scanning electron microscope (JEOL JSM-5310 LV, Japan) in low vacuum mode between 15 and 20 kV. Images were processed for display using SemAforE software (JEOL AB, Japan).

## Results

All veneers were completely and easily removed from the tooth using the Er:YAG laser and in case of partial debonding, the remaining veneer structure was eliminated in the same conditions, we previously described. In case of partially debonded veneer, irradiation continued until no veneer structure was observed. Irradiation was stopped only when no veneer structure was macroscopically observed.

The pulse number, registered automatically by the device ranged from 17157 to 4077 (mean range 9836, 25) [Table 1] and great standard deviation value was registered (4501, 91). The average removal time was 328 s (Standard deviation 156 s), while the removal time ranged from 136 to 572 s.

SEM observations [Figures 1-4] confirmed that residual tooth structure is not altered when using low fluences, we used for this study.

In addition, the removal occurred without ablating or damaging any tooth structure as observed in SEM analysis. On all specimens, the typical structure of the veneer cement covered the surfaces.

## Discussion

In these experimental conditions, all the irradiated veneers were debonded, eight of them entirely, four into two or three parts: The removal occurred without damaging any tooth structure as showed by SEM images.

To avoid the fracture of the veneers during laser debonding, an important factor may be represented by the way of the insertion in the tooth: in fact, it is better if the veneer had

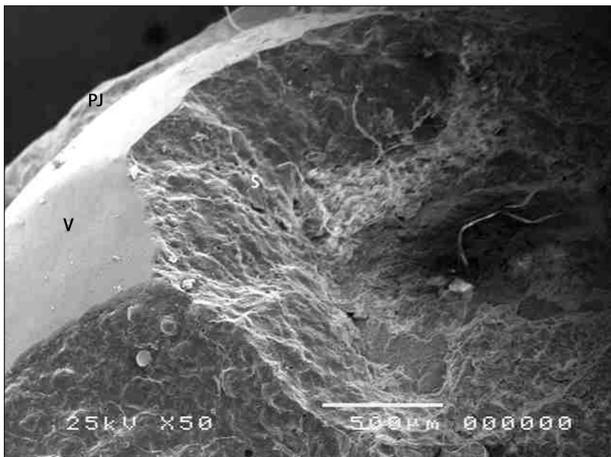


Figure 1: Broken veneer after irradiation (PJ: Peripheral joint, V: Veneer broken, S: Sealer)



Figure 2: Broken veneer (V), sealer (S), and spot size (SS) on tooth surface

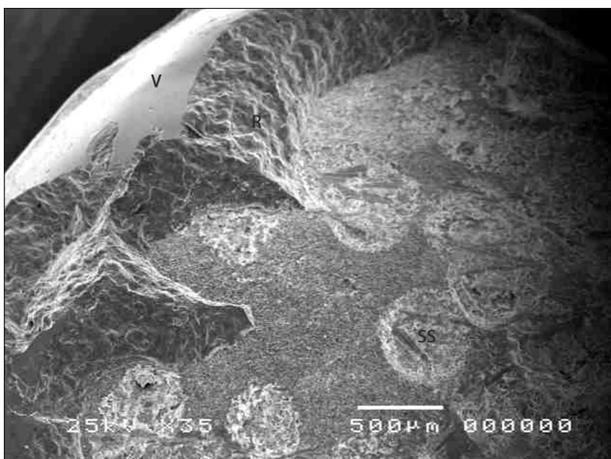


Figure 3: Veneer debonding: Spot size (SS) of about 0.5 mm corresponding approximately to the diameter of the laser sapphire tip



Figure 4: Peripheral preparation with chamfer bur (C) and debonded veneer. The surface is covered with smooth

been misplaced and needs to be repositioned, as confirmed by Morford *et al.*,<sup>[14]</sup> and the optimization of the used parameters may allow us to obtain this result in the totality of debonding procedures.

A great standard deviation value was registered, and this is very difficult to explain, due to multiple parameters involved. Even if one of the possible biases has been surely avoided by the utilization of the same operator for all the tests, there are different factors influencing the procedure as the width of the samples, the quality of the cementation, the time to reach the peak power after each stop and restart, and unfortunately, their respective influence on veneer debonding is unknown.

It is to underline that, when, in the literature, it is affirmed that the time for debonding with quite the same parameters does not exceed 4 min, in this evaluation it is necessary to distinguish between working time and irradiation time that, when using pulsed lasers, are very different (duty cycle). As an example, pulse duration of 800 μs. corresponds

to  $8.10^{-4}$  s (0.0008 s) and for a frequency of 30 Hz, the irradiation time per second becomes  $30 \times 0.0008$  s (0.024 s) while the resting time becomes  $1 - 0.024 = 0.976$  s.

The irradiation time was extremely short to cross the underside surface of the porcelains veneers and the relaxation time so long, when compared to the irradiation time.

On such biomaterials, there is no evidence of a relationship between relaxation time and absence of cracks because, theoretically, there is only a poor absorption of this wavelength in this kind of ceramics. The explication of the interaction may be linked with the presence of silica and polymethyl-methacrylate resin,<sup>[14]</sup> even in few quantities, in the dental ceramics, and they are able to absorb this wavelength.

In literature, it was previously confirmed that veneers do not show any water absorption while the bonding cement (Relyx) showed a broad H<sub>2</sub>O/OH absorption band<sup>[14]</sup> and initial signs of cement ablation starts with very

low fluences. In our observation, we confirmed that low fluences were sufficient to debond veneers.

### Conclusions

The veneer debonding by the use of Er:YAG laser allows the dentist to re-use the detached veneer in some clinical cases when preservation of this fixed prosthetics integrity is observed. This method is rapid.

Numerous future clinical investigations are requested to confirm or infirm the validity of the method. Moreover, some techniques of observation, such as energy dispersive spectroscopy are at the same time requested, to identify each component of the subsurface.

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### Conflicts of interest

There are no conflicts of interest.

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