ESEM Analysis of Enamel surface morphology Etched with Er,Cr:YSGG Laser and Phosphoric Acid: In Vitro Study

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ABSTRACT

Objectives: The aim of the present study was to evaluate the etching pattern of Er,Cr:YSGG and conventional etching on prepared samples of human enamel by environmental scanning electron microscope (ESEM).

Materials and Methods: Forty five freshly extracted human upper premolars were used; the teeth had been extracted for orthodontic reasons and were collected and stored in a solution of 0.1% (wt/vol) thymol. The teeth were mounted vertically in a self-cure acrylic cylinder. One clinician prepared all the teeth, in each tooth, a 4x4 mm area was treated in middle third of the buccal surface. The teeth were divided into three groups according to type of etching techniques (n=15). Group (A): enamel etched with 37% phosphoric acid for 30 s, thoroughly rinsed with distilled water for 60 s and gently air dried.; Group (B): enamel was irradiated with Er,Cr:YSGG laser ablated with an energy output of 4.5 watt/30hz and Group (C): enamel was irradiated with Er,Cr:YSGG laser ablated with an energy output of 4.5 watt/20hz. In group b & c Er,Cr:YSGG laser (2.78 μm wavelength) used for 15 sec at 45degree angulations working distance 5mm on a square size 4x4mm on buccal surface. Micro-morphological changes of enamel surface were evaluated using an environmental scanning electron microscope at X250 & X1500 magnification.

Results: In this study, laser with 30 Hz regards a definite change in the surface of the enamel, most of the enamel prisms are interrupted or assume an irregular outline. However laser with 20 Hz showed the ultra-structural appearance of enamel nearly similar to that of conventionally etched enamel with 37 percent phosphoric acid.

Conclusion: Within the limits of this in vitro study, both conventional acid etching & laser 20 Hz etching showed nearly similar effect on enamel surface, so the laser-etching can be successfully used as an alternative to the conventional acid-etch.
**Introduction:**
Enamel etching is an important step during composite restorative procedures. Experimental and clinical evidence suggest that failure in maintaining resin restoration marginal integrity could ultimately lead to: marginal microleakage (1,2), marginal discoloration (3) and pulpal inflammatory response (4,5). Therefore, the development of new techniques to increase the bond strength between the dental surface and the adhesive/composite resin systems (e.g. mechanical adhesion) may have profound therapeutic implications in dentistry. Among the various techniques currently in use to promote dental surface conditioning (6), high-output lasers, such as Er:YAG laser, have been studied as an alternative method to selectively remove oral mineralized tissues for restorative purposes (7,8,9). The therapy was based on the observation that a laser conditioned enamel surface has a modified calcium to phosphorus and carbonate to phosphorus ratio [10,11,12]. The percentage of water and organic substances is reduced [13] which leads to a less acid-soluble and therefore more caries resistant enamel surface [11,12]. Also laser conditioning might promote the formation of micro-spaces which in turn remineralize by trapping free ions and increase caries resistance [13]. The aim of the present study was to evaluate the etching pattern of Er,Cr:YSGG and conventional etching on prepared samples of human enamel by environmental scanning electron microscope (ESEM).

**MATERIALS AND METHODS**
Forty five freshly extracted human upper premolars were used; the teeth had been extracted for orthodontic reasons and were collected and stored in a solution of 0.1% (wt/vol) thymol.
Criteria for tooth selection: Intact buccal enamel not subjected to pre-treatment with chemical agents, such as hydrogen peroxide or enamel conditioner, with no cracks from the use of extraction forceps, and with no caries.
- The teeth were mounted vertically in a self-cure acrylic (Rapid Repair, Detrey Dentsply Ltd, Surrey, U.K.) cylinder. One clinician prepared all the teeth, in each tooth, a 4x4 mm area was treated in middle third of the buccal surface.
The teeth were divided into three groups according to type of etching techniques(n=15). Group(A): enamel etched with 37% phosphoric acid (3M Unitek, Monrovia, USA) for 30 s, thoroughly rinsed with distilled water for 60 s and gently air dried.; Group (B): enamel was irradiated with Er, Cr:YSGG laser ablated with an energy output of 4.5 watt/30hz and Group (C): enamel was irradiated with Er,Cr:YSGG laser ablated with an energy output of 4.5 watt/20hz. In group b & c Er, Cr:YSGG laser (2.78 μm wavelength) used for 15 sec at 45degree angulations working distance 5mm on a square size 4x4mm on buccal surface.
Micro-morphological changes of enamel surface were evaluated using an environmental scanning electron microscope at X250 & X1500 magnification.

**Results:**
**First group 30 Hz:**
A definite change in the surface of the enamel was noted at low power magnification (250x) as compared to the adjacent sound enamel. However, at a higher power magnification (1500x), Most of the enamel prisms are interrupted or assume an irregular outline. In some areas the enamel prism boundaries were indistinct giving a t
irregular surface with confluence of the prismatic and inter-prismatic structures. (Fig1)

Second group 20 Hz:
Scanning electron micrograph of group 2: A definite change in the surface of the enamel was noted at low power magnification (250x) as compared to the adjacent sound enamel. The normal appearance of the enamel prisms was maintained in most areas (honeycomb-like structure). However, confluence of the prismatic and inter-prismatic structure was noted in some areas, giving the enamel an irregular appearance with variable sized cracks (mag. 1500x). (Fig2)
A micro-roughened surface was observed at a low energy output level of 30 Hz, however, the depth of the roughened areas seemed lesser as compared to the higher energy output of 20 Hz.

**Third group acid etching:**
A definite change in the surface of the enamel was noted at low power magnification (250x) as compared to the adjacent sound enamel. There is loss of normal enamel architecture, with parts showing micro-porosities and surface irregularities (honeycomb-like structure) mag. 1500x (Fig3). A pronounced loss of enamel substance, predominantly in the areas of prism centers with simultaneous conversion of the margin was obvious, with peripheral micro-cleft formation. Deep furrows and globular debris were also noted.

![Fig.(3) Low-power magnification (250 x) and High-power magnification (1500 x) image of enamel surface after acid etching 37% phosphoric acid](image)

The ultra-structural appearance of enamel lasered at 20hz was nearly similar to that of conventionally etched enamel with 37 percent phosphoric acid.

**Discussion:**
The current study evaluate the etching pattern of Er,Cr:YSGG and conventional etching on prepared samples of human enamel by environmental scanning electron microscope (ESEM).
As a possible alternative to acid conditioning the use of laser therapy has recently shown a promising front [14]. Er,Cr:YSGG (Erbium, Chromium : Ytrium Scandium Gallium Garnet) laser, a hydrokinetic laser system having a wavelength of 2780 nm was investigated by Usumez et al., and was found to have ablating effect on enamel [15]
In this study, laser with 30 Hz regards a definite change in the surface of the enamel. It was noted at low power magnification as compared to the adjacent sound enamel. However, at a higher power magnification, Most of the enamel prisms are interrupted or assume an irregular outline. In some areas the enamel prism boundaries were indistinct giving a confluent irregular surface. However laser with 20 Hz showed, confluence of the prismatic and inter-prismatic structure was noted in some areas, giving the enamel assumed an irregular appearance with variable sized cracks (mag. 1500x).

Moreover laser with 20 Hz showed the ultra-structural appearance of enamel nearly similar to that of conventionally etched enamel with 37 percent phosphoric acid.

This finding is in agreement with other studied that showed that Issar et al., the predominant enamel etching pattern after laser etching seen was Type III as compared to the Type I in case of acid etching. Lin et al., using Er:YAG observed the same etching pattern [17]. However in a study by Patricia et al., typical honey comb pattern of etching (type I) was observed after irradiation by Er laser [18].

Olivi et al., the laser system analysed was found to be effective in removing human dental enamel [19], also Yildirim et al., the effects of Er, Cr: YSGG laser irradiation on bond strength of self-etch adhesive to enamel depend on laser pulse frequency and the test being used[20]. Lorenz reported that the ER,Cr:YSGG laser at 2W (5.6 J/cm2) a pattern similar to the type III acid etching pattern was described, they concluded that surface roughness after laser irradiation is reported to be similar or lower than with conventional etching [21].

However Emine et al., reported that enamel surface etching obtained with Er,Cr:YSGG laser (operated at 1.5 W and 1.75 W for 15 s) is comparable to that obtained with acid etching[22].

On the other hand, surface cracking was also evident in studies conducted by Usumez et al., Shuinn Lee et al., Tachibana et al., [15,23,24]. As lower power setting was used in a study by Torun Ozer et al., no cracks were reported in their study [25]. A study by Lin et al., showed that occasional cracks enhances retention and is ideal for resin penetration [26].

In this study, laser with 20 Hz regards the ultra-structural appearance of enamel nearly similar to that of conventionally etched enamel which were not present with 30Hz, this in agreement with studied by Uşümêz et al., Verma et al., Mizutani et al.,[15,27,28].

Thukral reported that ESEM analysis of enamel surface after Er,Cr:YSGG Laser irradiation showed the roughened enamel surfaces with intact morphology of the enamel prisms and complete absence of smear layer, so Laser-etching can be successfully used as an alternative to the conventional acid-etch. Skipping the step of acid-etching also helps save chair-side time and the results of the laser etched tooth surface are superior or at least comparable to that of an acid etched tooth surface [29].

**Conclusions:**
Within the limits of this in vitro study it can be concluded that both conventional acid etching & laser 20 Hz etching showed nearly similar effect on enamel surface, so the laser-etching can be successfully used as an alternative to the conventional acid-etch.

References


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