تأثير التخريش الليزري وحده أو متبوعاً بالتخريش الحمضي في الشكل السطحي للميناء: دراسة بواسطة المجهر الالكتروني الماسح

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الملخص

خلفية البحث وهدفه: ازداد استخدام الليزر وتطبيقاته في مجال طب الأسنان ازدياداً كبيراً في السنوات الأخيرة. يمكن للتخريش الليزري للميناء أن يقدم بديلاً للتخريش الحمضي المعتاد. إن هدف هذا البحث هو دراسة شكل سطح الميناء بواسطة المجهر الالكتروني الماسح بعد تعريضه لليزر، مع إضافة الحبر الأسود كمادة ممتصة للضوء أو من دونها، متبوعاً بالتخريش الحمضي أو غير متبوع.

مواد البحث وطرائقه: حضر السطح الميناِئي الدهليزي لطواحن بشرية مقلوعة حديثاً (20 طاحناً) مستوياً، وذلك باستخدام أقراص سحل ماسية، حيث قسمت الأسنان عشوائياً إلى أربع مجموعات: المجموعة 1: تطبيق الليزر وحده، المجموعة 2: الليزر + تخريش حمضي (10 ثوانٍ)، المجموعة 3: حبر أسود + ليزر، المجموعة 4: حبر أسود + ليزر + تخريش حمضي (10 ثوانٍ). طبق ليزر نوع (Nd:YAG) ضمن المعطيات الآتية: 160 ملي جول، 35 نبضة/ثانية، 5.6 واط، على المجاميع كلّها مدة 15 ثانية. درس شكل سطح الميناء المعالج بواسطة المجهر الالكتروني الماسح (SEM) وباستخدام قوى تكبير مختلفة.

النتائج: أدخل تعريض الميناء لليزر تغييرات في شكل السطح التي اختلفت بين المجموعات المدروسة، حيث نتجت خشونة أكثر عند إضافة الحبر الأسود في المجموعة 3 عند مقارنتها بالمجموعة 1. أظهرت مجموعات الليزر والتخريش الحمضي (المجموعتان2 و4) فضلاً عن التغييرات السطحية الموجودة في المجموعتين1 و3، مناطق من التخريش الحمضي المعتاد المرتبط بانحلال المواشير الميناِئية.

الاستنتاج: أنتج التخريش الليزري للميناء خشونة سطحية التي قد يكون ممكناً استخدامها لتثبيت الحشوات الراتنجية.

كلمات مفتاحية: تخريش ليزري، الميناء، مجهر الكتروني ماسح، تخريش حمضي

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The Effect of Laser Etching Alone or Combined With Acid Etching on the Surface Morphology of Enamel: A Scanning Electron Microscopic Study

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Abstract

Background & Objective: Laser use and applications in dentistry has increased dramatically in the last years. Laser etching of enamel may provide an alternative for conventional acid etching. The aim of this study was to evaluate, under Scanning Electron Microscope(SEM), enamel surface morphology after laser irradiation with or without the addition of photoabsorber (black ink); with or without acid etching. Materials&Methods: The buccal surface of twenty freshly extracted human molars was made flat by diamond abrasive discs and the teeth were randomly divided into four groups: Group 1: Laser only, Group 2: laser + acid etching (10 seconds), Group 3: Black ink + laser, Group 4: Black ink + laser + acid etching (10 seconds). All the groups were irradiated with Nd:YAG laser using the following parameters: 160 mj, 35 pulse/second., 5.6 watts for a total irradiation time of 15 seconds. The treated surfaces were examined with SEM using different magnification powers. Results: Laser exposure of enamel produced surface alterations and irregularities that differed among treatment groups. More surface roughness resulted when black ink was used in group 3 compared with group 1. Acid etching after laser irradiation in groups 2 and 4 showed, in addition to the surface irregularities found in groups 1 and 3, areas of conventional etching pattern of enamel prisms. Conclusions: laser enamel etching produced surface roughness that might be used for the infiltration and subsequent mechanical retention of resin.

Key words: Laser etching, enamel, scanning electron microscope, acid etching

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Introduction

Etching of enamel is considered a crucial step during composite restorative procedures. It has been shown that failure in maintaining resin restoration marginal integrity could lead to: marginal microleakage: marginal discoloration and pulpal inflammatory response (1). The acid etch method has been first described by Buonocore in 1955 (2) and consists of cleaning the enamel, etching it with 37% phosphoric acid, rinsing and drying it. This acid-etching method has been used to promote adhesion and to increase the bond strength of resins to enamel. However, this technique is not without some disadvantages. The wet, saliva-contaminated surface prevents the etching of enamel and, therefore, may decrease the bond strength of composite (3). Enamel etch by the acid can be complicated by the removal of surface, variability of penetration depth, and strong washing and drying affecting the bond strength. 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 (4). One of the effective methods may be to pretreat the enamel by laser radiation. For conditioning, less time is needed using the laser than when etching conventionally. Furthermore, drying the surface with the laser is very quick, efficient, and gentle (5).

The neodymium:yttrium-aluminium garnet, or Nd:YAG, laser has a wavelength of 1064nm and is usually operated in a pulsed mode. The Nd:YAG laser beam can be delivered through a fiber optic system. A red helium-neon marker laser is used to aim the invisible Nd:YAG beam, which offers a great advantage for clinical use (6). This laser wavelength is highly absorbed by pigmented tissue; the darker the tissue, the more readily this wavelength is absorbed (7), and are transmitted through water and enamel (8). Operators can induce absorption of the Nd:YAG wavelength into superficial enamel by placing an initiator (that is, a dark organic substance such as ink) on the area in which etching is desired (8,9).

It has been demonstrated that pulsed Nd:YAG laser on photoabsorbing dye coated enamel surface, can produce numerous microcavities and microfissures which may provide space for the retention and penetration of dental resin (10, 11). Sazak and colleagues (12) compared Nd:YAG laser, air abrasion and acid etching on enamel and dentin and concluded that the Nd:YAG laser created the most surface irregularity on both enamel and dentin. Ariyaratnam et al. (13) evaluated the shear bond strength of composite to acid-etched and Nd:YAG laser-treated enamel (without photoabsorber) and showed that laser treatment at higher exposures resulted in the formation of microcracks and fissures.

The aim of this study was to evaluate under scanning electron microscope, the surface morphological changes of dental enamel induced by Nd:YAG laser with and without photoabsorber and when followed by acid etching or not.

Materials and Methods

Freshly extracted human permanent molars were used in the study. The teeth were caries free and detected for the presence of cracks. Any tooth with cracks was excluded from the study. After washing and removal of soft remnants, the buccal enamel surface of the tooth was made flat by the use of diamond wheels with coarse, medium and fine grits. This was performed under running tab water for cooling with 5 seconds reduction time for each grit (15 seconds total). The laser used was Nd:YAG with 1064nm.wavelength (PulseMaster 600 IQ, American Dental Technologies, Corpus Christi, Texas, USA) using the following parameters for all the test groups: 160 mJ, 35 pulse/second (Hz), 5.6 watts. This laser has a fiber optic arm with 320µm diameter which was held perpendicular to the irradiated surface (14) by the aid of an articulating holder. The tip of the fiber optic arm was held 1mm. from the irradiated tooth surface which was a circular area of 4 mm diameter. A total number of twenty teeth were used and divided into four groups (number= 5 teeth for each group):

Group 1: laser irradiation alone (no ink coating), 15 seconds.

Group 2: laser irradiation alone (no ink coating), 15 seconds + acid etching with phosphoric acid 37% (Total Etch, ivoclar, vivadent, Germany) for 10 seconds followed by washing for 30 seconds, and drying (5seconds).

Group 3: black ink (Rotring, Germany) as a photoabsorber was placed over the irradiation area + laser irradiation, 15 seconds.

Group 4: black ink + laser irradiation 15 seconds + acid etching with phosphoric acid 37% for 10 seconds followed by washing for 30 seconds, and drying (5seconds).

The black ink was applied with the aid of small-head brush. The teeth were stored in distilled water at 37°C for 24 hours (16) before they were examined under SEM (Tescan, Vega II xmu, USA) at the Atomic Energy Commission of Syria, using different magnification powers; 20.00 KV (KiloVolt) and Low Vacuum Secondary Tescan Detector (LVSTD).

Results

The application of laser to enamel within the treatment groups produced different morphological changes. In group 1 when laser was used alone, the enamel surface appeared molten with micropores (Figure 1). A higher magnification revealed an interlacing pattern with many cracks (Figure 2). When laser application was followed by acid etch (group 2), it can be seen that the surface showed mixed areas of conventional acid etch patterns combined with molten areas similar to those found in group 1. Multiple cracks were also evident at higher magnification (Figures 3,4).

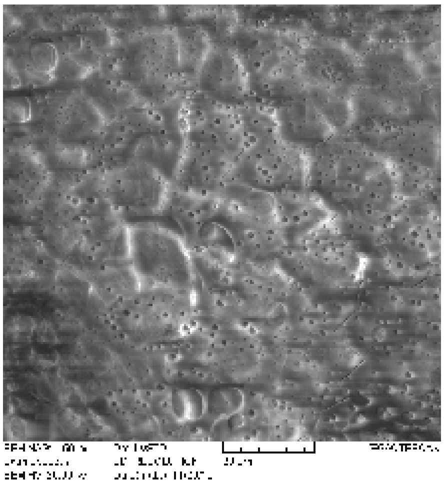

Figure (1): Group 1: Enamel surface showing melting and micropores (Magnification 1500x).

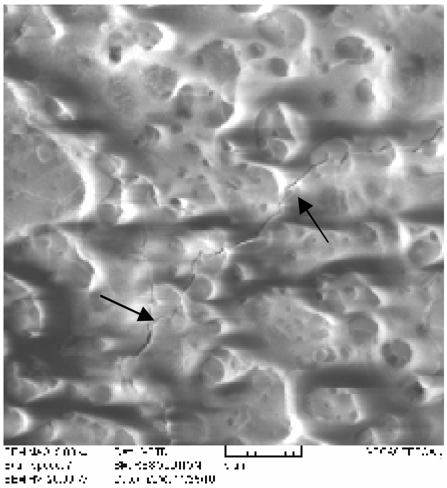

Figure (2): Group 1: Enamel surface showing interlacing and cracks (Arrows) (Magnification 5000x).

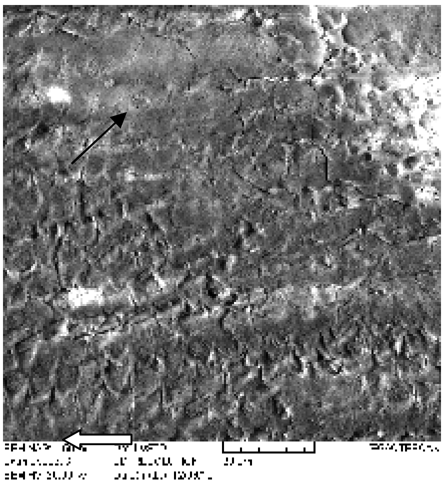

Figure (3): Group 2: Enamel surface showing conventional etching pattern (White arrow) and molten surface (Black arrow) (magnification 1500x)

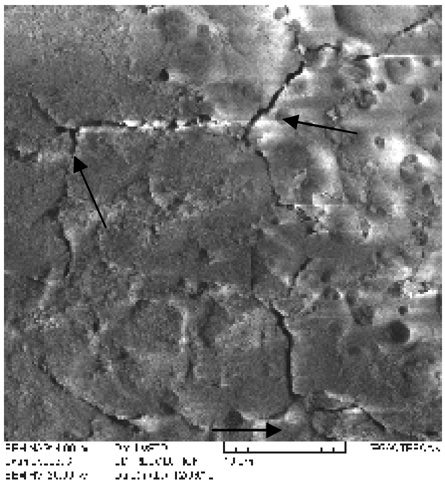

Figure (4): Group 2: Cracks on enamel surface(Arrows) (Magnification 4000x)

When black ink was placed before laser irradiation (group 3), the resulted surface (Figure 5) appeared to have a crater like appearance with multiple micropores that were more prominent and of larger diameters especially when compared with group 1 in figure (1). Numerous cracks extending along the surface can be seen (Figure 6).

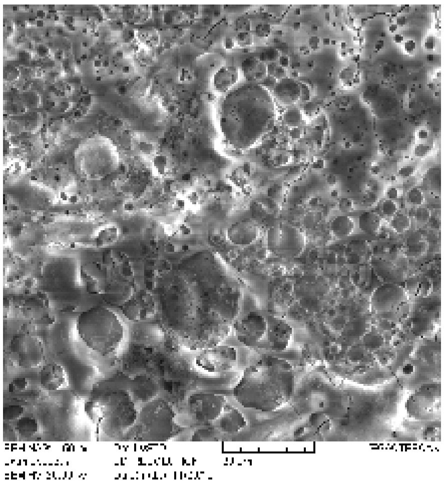

Figure (5): Group 3: Enamel surface with photoabsorber showing prominent craters and micropores (Magnification 1500x).

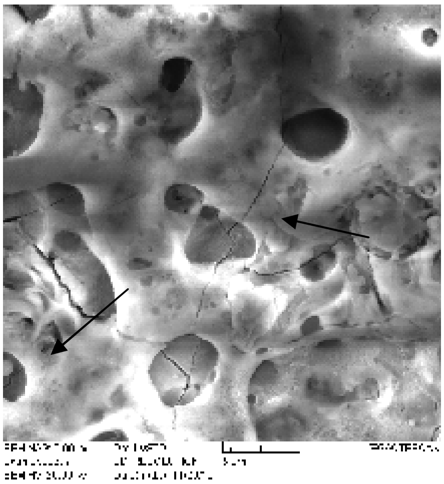

Figure (6): Group 3: Higher magnification of enamel surface in figure 5 showing cracks (Arrows) (Magnification 5000x).

In group 4, when acid etch was applied after laser irradiation of the coated enamel surface, the surface showed a mixed areas of conventional acid etch pattern (honeycomb appearance) with melting of enamel surface (Figure 7). However, the molten areas as well as cracks were more evident when compared with group 2 (Figure 3). The etching pattern that resulted from the application of phosphoric acid was similar in both groups 2 and 4 (Figure 8).

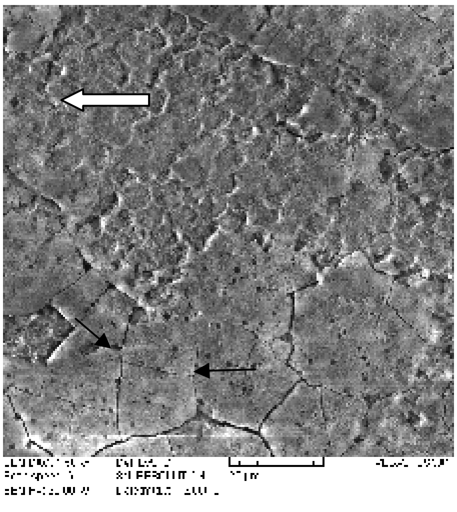

Figure (7): Group 4: conventional acid etch pattern (White arrow) and molten areas with cracks (Black arrows) (Magnification 1500x).

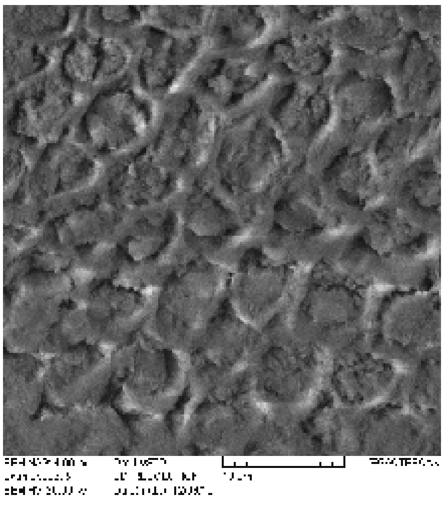

Figure (8): The acid etch pattern obtained in groups 2 and 4 (Magnification 4000x).

Discussion

This study was performed to compare the surface morphological changes associated with laser etching alone or with photoabsorber; combined with acid etching or not. The parameters used in this study were based on previous results that preferred the use of high energy levels for the purpose of tooth surface conditioning. Bedini and colleagues evaluated under SEM, the morphological variations of enamel when irradiated with Nd:YAG laser using different energy levels: 60 mJ energy, 10 Hz frequency and 0.6 W power; 120 mJ energy, 10 Hz frequency and 1.2 W power; 160 mJ energy, 15 Hz frequency and 2.4 W power. They suggested the use of higher energies since this produced surface changes that are more suitable for sealants and composite retention (14). Lin and Huang measured the shear strength of orthodontic brackets adhered to Nd:YAG laser etched enamel and found that the shear strength increased proportionately to energy density (15). von Fraunhofer and colleagues tested the shear strength of orthodontic brackets adhered to buccal enamel surfaces that were painted with black ink and irradiated with Nd:YAG laser. They found that only surfaces that received the higher energy setting (3 Watt) achieved the minimum acceptable shear strength (0.6 Kg/mm) for orthodontic bracket placement. Furthermore, they showed that a minimum irradiation time of 12seconds was required to remove all remnants of carbon based initiator (9).

Within the laser parameters used in this study, all the treatment groups showed variable surface morphology. The characteristic features were: enamel melting, micropores with crater like appearance, and cracks. These results are in agreement with those found in previous studies (14,17,18).

The surface melting of enamel found in this study is in agreement with other studies (8,19) and may be attributed to the high increase in temperature during laser irradiation that is sufficient to cause melting and fusion of enamel crystals. The surface features such as cracks and craters typical of infrared laser irradiated enamel are explained by stresses in enamel due to expansion and contraction through localized heating and shock waves associated with the beam's interaction with the tooth (20). Hess pointed out these bubble-like inculsions, cracks and fissure features produced on the enamel surface greatly increase surface area, and may possibly be used for mechanical retention for dental restorative materials (11).

In group 3 when black ink was applied prior to laser exposure, an obvious increase in surface roughness and craters' diameter was evident (Figures 5, 6) in addition to enamel melting. This finding is in agreement with Boari et al., (8) ; Jennett et al. (21), and McNally et al. (22) who showed that the placement of photo-absorbing dyes in combination with pulsed lasers leads to a significant increase in tissue absorption and confines the energy penetration to a small volume. Also, this study supports the results provided by Hess (18) who studied, under SEM, subsurface morphologic changes of enamel coated with india ink and lased with Nd:YAG laser and showed a delicate interlacing pattern of thin partitions and small knob-like expansions.

The application of phosphoric acid after laser irradiation in groups 2 and 4 (Figures 3,4 and 7) resulted in the appearance of conventional etch pattern, that is dissolution of enamel prism and core (Figure 8), in addition to the craters produced by laser application. However, this dissolution was only partial which may be due to the short acid etching time(10 seconds) used in the study. Shorter etching times after laser irradiation were found to enhance composite adhesion to enamel (23) and to dentin (24).

Conclusions

Within the laser parameters used in this study, it can be concluded that laser etching in all treatment groups produced melted and rough enamel surface with craters, interlacing appearance in addition to cracks. The surface roughness was greater when black ink was used as a photoabsorber. Phosphoric acid application after laser resulted in mixed type of surface irregularities that is conventional acid etched enamel pattern combined with craters and cracks seen in other groups. Partial dissolution of enamel prism and core was seen when phosphoric acid was applied for 10 seconds. Laser etching can provide a rough enamel surface with micropores and craters that might be used for mechanical resin bonding. However, additional studies are required to validate our results.

Suggestions

Shear bond strength of composite adhered to enamel surface subjected to the four treatment regimens used in this study is needed to compare the results and to find the best method that is suitable to provide sufficient resin-enamel bonding.

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