International Journal of Paediatric Dentistry 2005; **15:** 205–209

Acid-etched and Erbium:Yttrium Aluminium Garnet laser-treated enamel for fissure sealants: a comparison of microleakage

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Summary. *Objectives.* A pilot study aimed to compare the microleakage of pit and fissure sealants in acid-etched and Erbium:Yttrium Aluminium Garnet (Er:YAG)-treated enamel. *Methods.* Forty permanent noncarious young molars and premolars, which were extracted for orthodontic reasons, were selected. The teeth were divided into four groups, with five molars and five premolars in each group. The groups were treated as follows: (1) group A – laser irradiation of the enamel of the occlusal surface without contact and in scanning mode was carried out using an Er:YAG laser, placement of sealant material, light curing, and thermocycling between 6° and 55 °C; (2) group B – the same as group A, but with no thermocycling; (3) group C – acid etching of the enamel surface, placement of sealant material, light curing and thermocycling; and (4) group D – the same as group C, but with no thermocycling. After being immersed in 1% methylene blue solution, all teeth were sectioned in the mesio-distal dimension into four slices. Images of the slices were then scanned to a Macintosh G3 computer and examined for marginal leakage. Leakage was measured by the degree of dye penetration. Three independent examiners evaluated the dye penetration.
Results. No penetration of dye material was observed in any of the slices in any of the four groups by any of the examiners.
Conclusions. No difference in microleakage was seen between lasing or acid etching, and therefore, the results of the present study would suggest that the technique may be efficacious.

Introduction

Sealing occlusal pits and fissures in teeth is a common and highly effective caries preventive method [1–3]. The purpose of sealing the pits and fissures is to prevent plaque microflora and food debris accumulating in the fissures where saliva cannot reach and clean the debris, remineralize initial lesions, and buffer acid produced by cariogenic bacteria [3].

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Resin-based sealants as well as glass ionomer materials are used for pit and fissure sealing. The former require the use of acid for preparing (etching) the enamel surface of the teeth. The tooth surface is then rinsed and dried before the sealant material is applied [3]. The success of this procedure depends on the isolation of the teeth and the prevention of any contamination of the etched enamel surface by saliva or water. Moisture contamination of the enamel may lead to reduced penetration of the sealant, and therefore, microleakage of bacteria at the margins of the sealed areas, which may, in turn, increase the chances of caries developing [4]. Tooth isolation may be achieved by the use of cotton

rolls or a rubber dam. Both techniques require skill and precision, and are time consuming [4,5].

In recent years, a new technique for caries removal and cavity preparation has been introduced, i.e. laser irradiation. Lasers with a wide range of characteristics are available today and are being used in the several fields of dentistry. Laser energy is absorbed by the dental enamel, promoting superficial modifications which may have clinical significance.

One such a laser is the Erbium:Yttrium Aluminium Garnet (Er:YAG, wavelength = 2·94 μm). When laser energy of this wavelength is absorbed in the water of the hard tissues, a rapid volume expansion of the vaporizing water occurs as a result of a substantial temperature elevation in the interaction site [6]. Microexplosions are produced, causing hard tissue disintegration. Short, high-energy pulses allow effective tissue removal with almost no temperature elevation to the surrounding tissues [7]. Studies have shown that the use of an Er:YAG laser to treat dental hard tissues is both safe and effective for caries removal, cavity preparation and enamel etching, and was approved by the US Food and Drug Administration in 1997 [8]. The preparation of the tooth surface by laser does not require the isolation of the tooth, and thus, can save the dentist this step prior to applying the sealant material on the enamel surface.

Several studies have been conducted to compare sealants placed on laser- or acid-conditioned enamel. In 1996, a split mouth clinical trial was undertaken to compare the retention of fissure sealants placed using both methods that found that, after a mean follow-up period of 14·5 months, the retention rate for CO_2 laser conditioning was greater than that for acid etching (97·9% versus 94·6%, respectively), although this difference was not statistically significant [9]. In their *in vitro* study, do Rego & de Araujo compared the effect of different surface preparations on the microleakage of pit and fissure sealants, and found that Nd:YAG laser irradiation with an energy level of 120 mJ per pulse and an energy density of 1·4 J cm^{-2} did not decrease the microleakage degree when using a fluoride-resin-filled sealant and resin-modified glass ionomer cement as pit and fissure sealants [10].

Recently, it has been shown that occlusal surfaces treated exclusively by a very short pulsed Er:YAG laser (120 mJ at a frequency of 4 Hz under air–water spray for 30 s) showed poorer marginal sealing than those treated by acid-etching alone [11].

Since the data regarding the quality of pit and fissure sealants placed after surface preparation with laser are not conclusive, and only a limited number of studies are available where Er:YAG has been used, the aim of the present research was to perform a pilot study which compared the microleakage of pit and fissure sealants in acid-etched and Er:YAG-treated enamel.

Materials and methods

Forty permanent, noncarious young molars and premolars which had been extracted for orthodontic reasons were selected and stored in sterile saline. All patients had agreed to their dentists that the extracted teeth could be used for research purposes. The roots of all the teeth were removed, using an E-1 high speed diamond bur, at the cemento-enamel junction, to facilitate the handling of the specimens. The teeth were divided into four groups, with five molars and five premolars in each group. The groups were treated as follows:

- *Group A* – Laser irradiation of the enamel occlusal surface without contact and in scanning mode was done using an Er:YAG laser (Opus 20 by Opus Dent, Netanya, Israel) with 800 mJ per pulse and 12 pulses per second, placement of sealant material (Helioseal, Vivadent, Schaan, Lichtenstein), and light curing using a conventional light source (Heliolux, Vivadent) for 20 s. The teeth were stored in saline at room temperature. After 48 h, thermocycling at 750 cycles in baths at 55 and 6 °C, cycled for 10 s in each bath under electronic control, was carried out.
- *Group B* – The same as group A, but with no thermocycling.
- *Group C* – The occlusal surfaces were etched with 37% phosphoric acid gel for 30 s, rinsed with air–water spray for 20 s and gently air-dried. Sealant material (Helioseal) was placed and light cured using a conventional light source (Heliolux) for 20 s. The teeth were stored in saline at room temperature. After 48 h, thermocycling at 750 cycles in baths at 55 and 6 °C, cycled for 10 s in each bath under electronic control, was carried out.
- *Group D* – Same as group C, but with no thermocycling.

All crowns were then covered with three layers of nail varnish (Enamel 'Blues', Careline, Luxemburg), except for the occlusal surfaces, and immersed in 1% methylene blue solution for 24 h.

After being immersed in the 1% methylene blue solution, all crowns were sectioned in the mesio-distal dimension using a diamond blade saw (Buehler Isomet, Lake Bluff, IL, USA) running at low speed into four equal slices, each 1 mm thick. This form gives six surfaces to examine, each surface with two edges with microleakage potential, i.e. 12 edges per tooth, resulting in 120 edges with microleakage potential. Slices were then photo-scanned (at 300 dpi) into a Macintosh G3 computer and examined for marginal leakage. Leakage was measured by the degree of dye penetration (in millimetres).

Results

No penetration of dye material was observed in any of the slices in any of the four groups by any of the examiners (0 mm): (A) laser-prepared surface with thermocycling; (B) laser-prepared surface with no thermocycling; (C) acid-etched surface with thermocycling; and (D) acid-etched surface with no thermocycling.

Discussion

The laser irradiation technique has the potential to be used in many dental procedures. Therefore, it could be of great benefit to the dentist if, by changing parameters in the same laser device, then she or he was able to perform various dental procedures previously done by other instruments or techniques. Placement of pit and fissure sealants is a technique-sensitive procedure requiring complete dryness of the tooth surface prior to acid-etching when a resin-based sealant is used. A series of steps leads to the final placement of the sealing material, including drying, applying etching material, rinsing, drying again and only then applying the sealant. The present study was designed to compare the quality of sealants placed after preparation of the occlusal surface by laser or acid-etching by testing the leakage of dye at the margins of the sealants.

The study showed no marginal leakage at all after conventional acid-etching, or after lasing the occlusal surface of molar and premolar teeth. This finding was observed even after the samples were thermocycled. The purpose of the thermocycling procedure was to simulate the thermal conditions existing in the oral cavity. It has been suggested that the thermocycling regimen should include short dwell times and several thousand cycles [12].

While no marginal leakage was observed in the present study, do Rego & de Araujo found that all teeth demonstrated dye penetration after teeth were treated with laser and acid-etching [10]. This difference may be explained, in part, by the differences in sealant material used and by the different characteristics of the laser used (Nd:YAG 120 mJ per pulse by do Rego & de Araujo, Er:YAG 800 mJ per pulse in the present study).

The current findings also contrast with those of Borsatto *et al*. [11], who used an Er:YAG laser and reported poorer marginal sealing after using a laser than after acid-etching. Again, this may be caused by a difference in the characteristics of the lasers used. The present authors cannot give any other satisfactory explanation regarding the difference between their study and that of Borsatto *et al*.

The current study had some limitations. The dye material used was 1% methylene blue. Using other dye solutions (e.g. 0·2% rhodamine, 0·5% solution of basic fuchsin or 50% silver nitrate) could have produced different results, probably because of a smaller particle size. Furthermore, the laser and conventional etching were compared only with respect to marginal leakage. It may be that different environmental conditions for teeth and/or different ecologies in various mouths may influence the microleakage of the sealant placed using either technique in the long run. Furthermore, other parameters must be considered when comparing both techniques, such as long-term retention, the integrity of the sealant or the shear strength of the sealant. Nevertheless, despite its limitations, the present study provides some data to support further research into the use of lasers in the performance of more dental procedures.

Conclusion

No statistical differences between the two types of surface preparation were observed when microleakage was assessed.

Résumé. *Propos*. Etude pilote visant à comparer les micro-percolations de scellements de puits et fissures avec traitement de l'émail par mordançage et par Erbium:YAG (Er:YAG).
Méthodes. 40 prémolaires et molaires permanentes jeunes non cariées, extraites pour raison orthodontique, ont été sélectionnées. Les dents ont été divisées en quatre groupes de cinq molaires et cinq prémolaires chacun. Les groupes ont été traités

comme suit : Groupe A – irradiation laser de l'émail de la face occlusale sans contact et sur un mode de balayage menée à l'aide du laser Er YAG et placement du scellement, photopolymérisation, thermocyclage entre 6° et 55 °C.

Groupe B – Identique à A sans thermocyclage.

Groupe C – Mordançage acide de la surface amélaire, placement du scellement, photopolymérisation, thermocyclage.

Groupe D – Identique à C, sans thermocyclage.

Après immersion dans du bleu de méthylène à 1%, toutes les dents ont été sectionnées dans le sens mésio-distal en quatre tranches. Les images des tranches ont été numérisées sur ordinateur Macintosh G3 et examinées pour l'étanchéité marginale. La percolation a été mesurée comme le degré de pénétration du colorant. Trois examinateurs indépendants ont évalué la pénétration du colorant.
Résultats. Aucune pénétration du colorant n'a été observée dans les tranches des quatre groupes.
Conclusions. Aucune différence de micropercolation n'a été vue entre le traitement laser et le mordançage. Les résultats de l'étude demanderaient donc que la technique soit efficace.

Zusammenfassung. *Ziel*. Diese Studie wurde unternommen um die Dichtigkeit von Fissurenversiegelungen nach Säureätztechnik sowie Erbium:YAG (Er:YAG)-Vorbehandlung des Schmelzes zu vergleichen.
Methoden. 40 bleibenden jugendliche kariesfreie Molaren (aus kieferorthopädischen Gründen extrahiert) wurden ausgewählt. Die Zähne wurden in vier Gruppen eingeteilt, 5 Molaren und 5 Prämolaren in jeder Gruppe. Die Gruppen wurden folgendermaßen behandelt:

Gruppe A: Laserbehandlung der okklusalen Schmelzoberfläche, Versiegelungsmaterial auftragen, Lichthärtung, Thermozyklus zwischen 6° und 55°.

Gruppe B: Wie Gruppe A ohne Thermozyklus.

Gruppe C: Schmelzätzung, Versiegelungsmaterial auftragen, Lichthärtung, Thermozyklus.

Gruppe D wie C ohne Thermozyklus.

Nach Einlegen in 1%ige Methylenblaulösung wurden alle Zähne in mesiodistaler Richtung getrennt i vier Scheiben. Bilder der Schnitte wurden eingescannt und mit einem Macintosh G3 Computer auf Undichtigkeit hin ausgewertet.

Die Undichtigkeit wurde anhand des Grades an Farbstoffpenetration durch drei unabhängige Untersucher ermittelt.
Ergebnisse. Es wurde in keinem der Schnitte aus allen vier Gruppen Farbstoffpenetration festgestellt. Schlussfolgerungen. Es konnten keine Unterschiede bezüglich Undichtigkeit zwischen der Laservorbehandlung und der Säureätztechnik festgestellt werden.

Resumen. *Objetivo*. Un estudio piloto dirigido para comparar el microfiltrado de un sellador de fisuras en esmalte tratado con grabado ácido y con Erbium YAG-(Er:YAG).
Métodos. Se seleccionaron 40 molares permanentes y premolares jóvenes sin caries que fueron extraídos por razones ortodóncicas. Los dientes se dividieron en cuatro grupos, 5 molares y 5 premolares en cada grupo. Los grupos se trataron de la manera siguiente:

Grupo A – Irradiación con láser del esmalte de la superficie oclusal sin contacto mediante el uso de Er:YAG láser en modo escáner, colocación del material sellador, fraguado por luz, termociclado entre 6° y 55 °C.

Grupo B – Lo mismo que en A pero sin termociclado.

Grupo C – Grabado ácido de la superficie del esmalte, colocación del material sellador, fraguado por luz, termociclado.

Grupo D – Lo mismo que en el grupo C, sin termociclado.

Después de sumergirse en una solución de metileno al 1%, todos los dientes se seccionaron en sentido mesio-distal en cuatro cortes. Las imágenes de los cortes se escanearon luego con un ordenador Macintosh G3 y se examinaron en busca de filtrado marginal. El filtrado se midió según el grado de penetración del colorante. Tres examinadores independientes evaluaron la penetración del colorante.
Resultados. Los examinadores no observaron penetración de material colorante en ninguno de los cortes de los cuatro grupos.
Conclusiones. No se observaron diferencias en el microfiltrado entre el láser y el grabado ácido y por tanto los resultados del estudio señalarían que la técnica puede ser eficaz.

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