

Temperature Rise Induced by Light Curing Unit Can Shorten Enamel Acid-Etching Time

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Abstract

Objectives: The aim of this in-vitro study was to assess the thermal effect of light emitting diode (LED) light curing unit on the enamel etching time.

Materials and Methods: Three treatment groups with 15 enamel specimens each were used in this study: G1: Fifteen seconds of etching, G2: Five seconds of etching, G3: Five seconds of etching plus LED light irradiation (simultaneously). The micro shear bond strength (μ SBS) of composite resin to enamel was measured.

Results: The mean μ SBS values \pm standard deviation were 51.28 ± 2.35 , 40.47 ± 2.75 and 50.00 ± 2.59 MPa in groups 1, 2 and 3, respectively. There was a significant difference between groups 1 and 2 ($P=0.013$) and between groups 2 and 3 ($P=0.032$) in this respect, while there was no difference between groups 1 and 3 ($P=0.932$).

Conclusion: Simultaneous application of phosphoric acid gel over enamel surface and light irradiation using a LED light curing unit decreased enamel etching time to five seconds without compromising the μ SBS.

Keywords: Acid Etching, Dental; Dental Enamel; Curing Lights, Dental

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INTRODUCTION

The resin-to-enamel bond following etching of the enamel surface with phosphoric acid was first described by Buonocore in 1955 [1]. It has been suggested that etching duration is a factor that can influence the bond to enamel [2-5], but the optimal enamel etching time varies depending on several parameters namely content and concentration of acid used, physical state of the etchant, duration of etching and rinsing, method of activation, enamel surface instrumentation, patient's age, chemical composition and condition of enamel, primary or permanent tooth, prism structure,

previous exposure to fluoride and demineralization [3,4].

At first, the recommended time of acid etching was 30 seconds for 85% phosphoric acid [1]. In the 1960s, it was extended to 60 seconds [6,7]. In the 1980s, the recommended etching time was reduced to 30 seconds. Extending the etching time to 60 seconds has been shown to produce rougher enamel surfaces with no enhancement of bond strength [8]. Meanwhile, some authors recommended reducing the etching time to 15 seconds when 32% to 40% phosphoric acid gel was used [9], as it did not significantly reduce the bond strength of

composite resin or orthodontic brackets to enamel [8-10].

Uncut enamel on the surface of permanent teeth is more acid resistant to cut enamel because of higher fluoride content, and aged enamel may require an extended etching time up to 60 seconds. Moreover, primary teeth may need extended etching time. Most of the manufacturers of adhesive systems have recommended 15 seconds because it saves chair side time without compromising the adhesive performance [11]. This time duration is considered adequate for creating a retentive enamel surface with no difference in the enamel etching pattern [12] or decrease of bond strength to instrumented enamel [9,13,14]. Adversely, it is generally believed that shorter etching times may compromise bond strength and durability [8], but some previous studies have suggested that shorter enamel etching time may be efficient. A laboratory study by Beech and Jalaly in 1980 [14] showed no significant differences in SBS among five-, 15- and 60-second etching times for bonding orthodontic adhesive resin to enamel. More recently, self-etching adhesives were introduced; these adhesive systems have an acidic pH that creates some etching effects on the enamel and dentin. While a separate etching step for dentin is widely believed to be unnecessary, there is a general consensus that selective etching of enamel can still have benefits for self-etching adhesives and the latest multi-mode universal adhesives.

Clinicians are interested in approaches and techniques that can help reduce chair time without compromising the result. In this manner, a reduced etching time of enamel appears to be an interesting topic to explore. In theory, an accelerated interaction of phosphoric acid with enamel should be able to reduce the etching time. From the chemical point of view, etching capability of a reagent can be increased either by increasing the temperature of the etching solution or by changing the concentration of the reactants.

Absorption of photons at specific wavelengths has been considered as an effective approach for local temperature rise.

In this manner, several previous works in the dental field have focused on methods to raise temperature of professionally applied bleaching gels. It has been suggested that the use of light curing units commonly available in dental practices can also be effective in this regard.

Among the different types available today, LEDs have the advantage of narrower spectrum which promoting photo-chemical reactions at their respective wavelength (typically around 470 nm) without generating excessive heat [15,16].

There is no report in the literature on the effect of temperature rise induced by light curing units on enamel etching. Therefore, the aim of this in-vitro study was to assess the thermal effect of LED light curing unit on the enamel etching time. The μ SBS of composite resin to enamel was evaluated. The null hypotheses were that reducing the enamel etching time from 15 seconds to five seconds would not affect the μ SBS of composite resin to enamel, and that the application of LED light simultaneously with five seconds of etching would not affect the μ SBS of composite resin to enamel.

MATERIALS AND METHODS

This study was approved by the Ethical Committee of Shahid Beheshti Dental School (approval ID: 91512). Extracted human permanent molar teeth stored in 0.5% chloramine T solution were cut approximately 1mm below the cemento-enamel junction. After the teeth were mesiodistally sectioned, buccal and lingual coronal enamel surfaces were flattened by gentle polishing using 600-grit silicon carbide papers under running water. All the sections were free of caries, restorations, cracks or stains. The prepared enamel sections were randomly distributed into three treatment groups (n=15).

Table 1. Statistical analysis of microshear bond strength (MPa)

Groups	Mean±Std. Error	95% Confidence Interval for Mean	Minimum	Maximum
G1	51.28±2.35	46.24-56.32	39.77	65.52
G2	40.47±2.75	34.57-46.36	24.17	56.05
G3	50.00±2.59	44.43-55.53	33.68	66.05

Group 1 (G1) received 15 seconds of etching. In group 2 (G 2), the gel was left undisturbed for only five seconds and Group 3 (G 3) had a five-second acid-etching time with LED light irradiation (1200mW/cm²) simultaneously (LE Demetron II, Kerr, Orange, CA, USA). In G1, 37% phosphoric acid etchant gel (Super Etch, SDI, Bayswater, Australia) was applied with a small brush using a continuous brushing method, while in G2 and G3 the etchant gel was left undisturbed on the enamel surface. After that, the etchant was thoroughly rinsed with air and water spray, and then the surface was air-dried. On each enamel surface, a thin layer of light-cured unfilled resin (Margin Bond, Coltene, Altstätten, Switzerland) was applied with a micro brush. The bonding agent was cured for 10 seconds with a LED unit. Bonding of composite cylinder to the pretreated enamel surface was achieved by packing light-cured composite resin (Filtek Z 250 3M ESPE, St. Paul, MN, USA) with A2 shade into a cylindrical plastic tube (Tygon tubes, Norton Performance Plastic Co., Cleveland, OH, USA), which was placed on the bonding substrate. The internal diameter of the tube was 0.7mm and the height was 1mm. The composite was light cured for 20 seconds. After one hour at room temperature (23°C), the Tygon tubes were cut with a scalpel and removed from the substrates; the specimens were finally stored in distilled water in an incubator (37°C) for 24 hours. The μ SBS test was carried out with a testing machine (Microtensile Tester, Bisco, Schaumburg, IL,

USA). In order to modify the design of this testing apparatus for μ SBS test, a flat metal plate was used with three perpendicular metal cylinders 0.7mm in diameter and 8, 9 or 10 mm in height along a straight line. This plate was attached with cyanoacrylate glue to the microtensile jig in order to enable wire loop μ SBS test.

The force was applied to each composite cylinder at a crosshead speed of 1mm/min using an orthodontic wire (0.2 mm in diameter) looped around the composite cylinder and a metal cylinder until the failure occurred. The load at fracture was recorded and μ SBS in MPa was calculated by dividing the fracture load (N) by the bonding surface area (mm²) [17]. The statistical analysis was performed by comparing the mean μ SBS values among the groups using one-way ANOVA followed by Tukey's HSD post-hoc test in SPSS 19 at a significance level of 0.05.

RESULTS

The results of μ SBS test are presented in Fig. 1 and Table 1. The mean μ SBS values±standard deviation were 51.28±2.35, 40.47±2.75 and 50.00±2.59 MPa in groups 1, 2 and 3, respectively. The statistical analysis suggested that there was a significant difference among the groups in this regard (P=0.009); post-hoc analysis showed that there was a significant difference between groups 1 and 2 (P=0.013) and between groups 2 and 3 (P=0.032), while there was no difference between groups 1 and 3 (P=0.932).

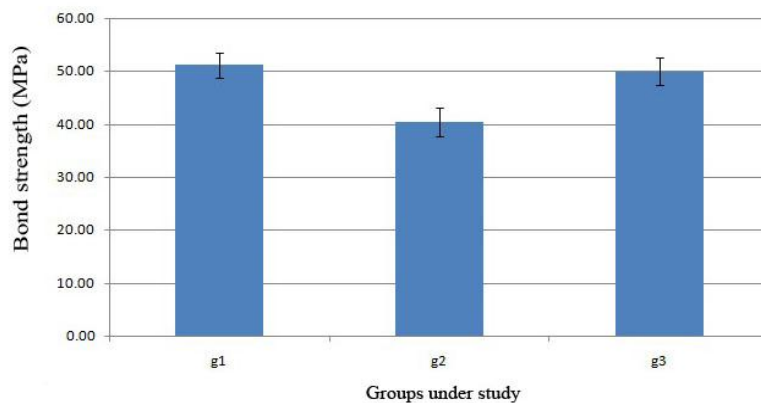


Fig. 1. The error bar of means and 95% confidence intervals of means bond strengths value in the study group. Microshear bond strength (MPa) of study groups

DISCUSSION

The null hypotheses of the study were rejected as the reduced etching time resulted in lower μ SBS to enamel, and LED light irradiation during five seconds of etching improved μ SBS to a level similar to that of 15 seconds of etching. These results confirm that application of LED light can accelerate and enhance the efficacy of enamel etching during the shortened etching period. The idea of using additional light or heat to activate the bleaching gel dates back to 1918, when Abbot [18] reported the use of high intensity light to increase the temperature of a bleaching agent applied to the tooth surface. When light is projected onto a bleaching gel, it is absorbed and its energy is converted to heat. Thus, irradiation of light can have thermal catalytic and photolytic effects [15]. Wavelengths with a high absorption coefficient in water and in tooth minerals are readily absorbed by the tooth surface, where heat conversion takes place. Asmussen and Peutzfeld [19] showed that temperature rise induced by light curing unit was correlated with power density of light. It was concluded that temperature rise for a LED device with a power density of 780 mW/cm^2 was around 9°C after 20 seconds of irradiation, which was not significantly different from that of a quartz tungsten device with power density of 650 mW/cm^2 .

Gomes showed that the temperature increase at the light guide tip in units with power density of more than 1000 mW/cm^2 was around 35°C after five seconds of irradiation [19]. It should be noted that excessive heat on the tooth surface might damage the pulp in vital teeth. It was shown that there was a wide range of differences in temperature rise among light curing units ranging from 4.10°C to 14.60°C over 60 seconds of application. However, the temperature rise after five seconds of application of LED light is unlikely to affect dental pulp, since the duration and temperature rise are limited and the absorbance of light by the etching gel will minimize the heat transferred to the underlying tooth structure. This speculation on rapid and superficial temperature rise gains strength from the fact that LED irradiation was effective in improving bond strength.

Reducing the etching time from 15 seconds to five seconds appears to be a valuable approach, but from a clinical and practical point of view, this procedure will require an assistant to readily apply the LED light concomitantly with the application of etching gel on the tooth surface.

CONCLUSION

In conclusion, this study showed for the first time that application of phosphoric acid gel to

the enamel surface along with LED light irradiation decreased the enamel etching time to five seconds without compromising the bond strength.

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