

The effect of different etching times on the sealant bond strength, etch depth, and pattern in primary teeth

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Abstract

The optimum time for etching primary enamel is controversial. The objective of this study was to establish laboratory evidence of the minimum etch time of primary enamel to provide for effective retention of occlusal sealants.

One hundred thirty-two caries-free exfoliated primary teeth were varnished leaving 2 mm² enamel windows on smooth and occlusal surfaces. The teeth were divided randomly into 3 groups (I-III) for measurement of etch depth, examination of etch and sealant tag patterns, and determination of bond strength. Each group then was divided into 4 subgroups (A,B,C,D,) corresponding to the etch times 15, 30, 60, 120 sec. The etchant used was 37% H₃PO₄.

The etch and sealant tag patterns were observed using SEM on all tooth surfaces after the 4 etch times. No differences in etch or tag patterns existed in the subgroups.

Similar etch depths were seen on enamel surfaces after etching for 15, 30, and 60 sec (~10 μm), but a greater increase in depth was observed after the 120-sec etching (50 μm).

The bond strengths of the sheared sealant buttons were determined. The mean bond strengths in kg/cm² for 15, 30, 60, and 120-sec etches were 91 ± 77, 91 ± 61, 83 ± 42, and 83 ± 45, respectively. From this study it appeared that 60 sec is adequate time for etching primary enamel.

Extensive research in the field of occlusal sealants has been conducted for nearly 20 years. The results are both promising and substantial. However, despite the proven efficacy of sealants, questions regarding placement technique still exist. Certainly

controversy exists as to the optimum etching time for primary enamel.

Conniff and Hamby¹ and Silverstone^{2,3} reported that a 120-sec etch was necessary on primary enamel to establish proper etch patterns. Mueller and Tinanoff⁴ found that by increasing the etch time an increase in tag formation was seen. This later study also evaluated and supported the concept of abrading the primary enamel prior to etching with H₃PO₄.

Fuks et al.⁵ studied the etch pattern of primary teeth using different etch times and found that a 240-sec etch gave the desired etch pattern. Although they stated a 180-sec etch was adequate, they still found areas of smooth enamel when examined under a scanning electron microscope (SEM). However, despite the desirability of the 240-sec etch, the authors admitted to the difficulty of successfully isolating teeth for 4 min, especially in children.

In another study it was found that primary enamel should be etched for no more than 180 sec.⁶ The authors also decided areas subjected to wear should be etched for less time — about 90 sec. The authors did not give a reason for this statement, although it may be speculated that subsurface enamel exposed after wear may be more susceptible to etching than the normal enamel surface. Nordenvall et al.⁷ compared primary, young, and mature permanent teeth using varying etch times between 15 and 60 sec. They found that the 15-sec etch of primary teeth gave the greatest surface irregularity most consistently. Their work supported the idea of a shorter etch period although corresponding etch depths and bond strengths were not analyzed.

Bond strengths have been reported to determine the forces necessary to remove resin samples from

primary enamel after different etch times. Smutka et al. found no significant differences in the forces required to dislodge the sealant after 60, 120, and 240-sec acid applications to primary enamel.⁸

Simonsen^{9,10} compared clinically the longevity of sealants on primary teeth after acid etching their occlusal surfaces for either 60 or 120 sec. He noted no significant difference in sealant retention between the 2 etching times. What failures did occur were in the 120-sec etch group and he felt they were due to problems in patient management during the additional minute of acid application.

Ripa¹¹ studied the evidence both for and against etching of primary enamel for 60 sec or longer. He concluded that there was not enough evidence to support increasing the etching time more than 60 sec. He also felt that there was no good evidence to support the abrasion of primary enamel prior to etching.

Because of these conflicting results it was felt that it would be advantageous to determine the minimum amount of time necessary to etch primary enamel and still maintain good sealant retention. A shortened etch time would be beneficial by minimizing the time required for tooth isolation prior to sealant placement. It also may reduce the working time which should improve the cost effectiveness of sealing primary teeth.

Methods and Materials

Preparation of Human Primary Teeth

The 132 teeth used in this study were caries-free exfoliated primary molars. They were stored in a dilute thymol solution prior to test procedures. The teeth were polished for 20 sec using moderate pressure and a nonfluoride prophylactic paste. The teeth were painted with an acid-resistant colored varnish except for windows (2 mm diameter) on smooth surfaces (buccal, lingual, mesial, and distal). The teeth then were divided randomly into 3 groups (I-III) each containing 44 teeth. In Group I etch depth was measured; in Group II the etch and sealant tag pattern were examined; and in Group III the bond strength of the sealant was determined. Each group was divided into 4 subgroups (A,B,C,D — 11 teeth each) and corresponding to 1 of the following etching time periods: 15, 30, 60, and 120 sec. Eight of these teeth (2 from each subgroup) were selected randomly and, in addition to the etched smooth surfaces, the occlusal aspect also was etched for the specified time. The occlusal surfaces were included purely to compare the quality of the etch with that of the smooth surfaces; bond strengths were not analyzed.

Acid Etching

The etchant used was 37% H₃PO₄ and was applied using a 00 camel's hair brush. Each window was cov-

ered completely with 1 ml of acid and agitated continuously for the specified time. The surfaces then were rinsed with 3 ml distilled H₂O for 15 sec and air dried for 30 sec. The sealant used was a yellow, chemical-cured sealant.^a The same measured amount was mixed according to manufacturer's specifications for all experiments.

Direct Estimation of Etch Depth

Etch depth was measured directly on 100 μm thick, undecalcified sections of teeth taken from Group I, using a calibrated eyepiece graticule in a light microscope.

Etch and Sealant Tag Patterns

Twenty-two teeth from Group II were etched and viewed with SEM to examine etch patterns after the different etching times. The remaining 22 teeth were etched and the sealant was painted on the window. The enamel then was dissolved using 40% HCl, and the interface between enamel and sealant was observed using SEM.

The specimens were vacuum coated with Au and Pd prior to examination with the SEM. The etch and tag pattern were observed on both the smooth and occlusal surfaces. The etch depths for the shorter etching times also were observed using SEM because of difficulty in making measurements using the light microscope.

Bond Strength

For teeth in Group III, a 2-mm diameter rubber tube (orthodontic separator) was secured to the etched enamel window via sticky wax. After mixing, the sealant was poured and held until cured (60 sec). The teeth were stored at 37° C and 100% humidity for 24 hr and then were mounted in 1 3/4 × 1 1/4-in Cu tubings using dental stone. The orthodontic separator was cut off leaving the sealant button exposed. The jig was placed parallel to the long axis of the tooth allowing for analysis of shear strength of the sealant.

Data Collection and Analysis

The measurement of etch depths and the data gathered by bond strength determination were analyzed using analysis of variance. The SEM and light microscope studies compared photomicrographs of the different surfaces. These surfaces were categorized into Type 1, 2, and 3 etching patterns.²

^a Delton — Johnson & Johnson, Dental Products Co: East Windsor, NJ.

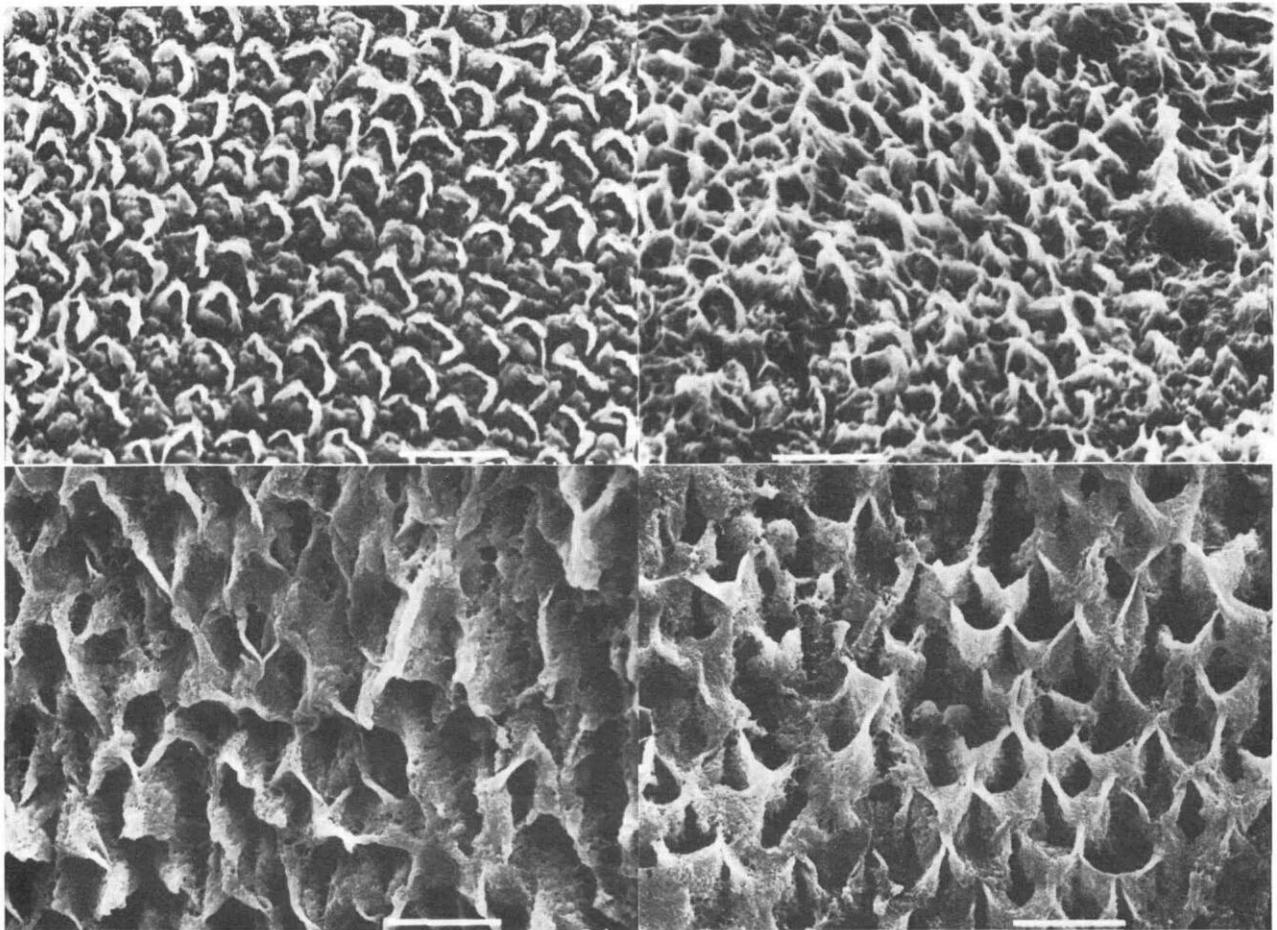


FIG 1. SEMs of the sealant tags after enamel dissolution in 40% HCl which are mirror images of etched enamel surfaces: (a) 15-sec etching; (b) 30-sec etching; (c) 60-sec etching; (d) 120-sec etching. The bar marker = 10 μm .

Results

The scanning electron photomicrographs showed the 3 etch patterns in all 4 subgroups. However, on all samples there were also areas of unetched enamel. The examination of the sealant tags revealed mirror images of the 3 etch patterns and unetched areas (Fig 1).

In Table 1 the bond strength values for all etching

TABLE 1. Bond Strengths in Kg/cm² of Sealant (Delton®) After Different Etching Times of Primary Enamel

	Etch Time			
	15 sec	30 sec	60 sec	120 sec
Mean	92	92	83	83
Standard deviation	± 77	± 61	± 42	± 42
Number of samples (Surface)	13	21	17	13
Range	6-231	14-249	27-170	14-159

periods can be seen. The mean bond strengths obtained after the 4 etching times were not significantly different ($p > 0.05$). However, the standard deviation of the bond strengths for 15- and 30-sec groups were somewhat larger (77 and 61, respectively) when compared to the 60- and 120-sec groups (41 and 43, respectively). The range of bond strengths also showed some variation between the 2 shorter and the 2 longer etch times. The lowest recorded bond strengths were relatively similar in all groups, but the 2 shorter etch periods gave maximum bond strength of ~ 240 kg/cm² whereas bond strength of the longer periods were ~ 165 kg/cm².

Table 2 shows the means of the etch depths for the 4 etching periods. There was a gradual increase in etch depth with increase in etching time — 15 sec, 9 μm ; 30 sec, 12 μm ; and 60 sec, 14 μm . However, after the 120-sec etch there was a significant increase to an etch depth of 50 μm .

TABLE 2. Etch Depths μm in Primary Enamel after Different Etching Times with 37% Phosphoric Acid

	Etch Time			
	15 sec	30 sec	60 sec	120 sec
Mean depths	9	12	14	50
SD	3.8	2.8	1.4	0

Discussion

The etch depth in primary enamel obtained after the different etching times showed, as would be expected, an increased surface enamel loss with an increased etching time. This loss, $\sim 10 \mu\text{m}$, was not very different for the 3 shortest etching times, but increased fivefold after 120-sec etching. This large increase may be due to etching subsurface enamel which is more soluble than the surface enamel. The removal of $50 \mu\text{m}$ of enamel seems to be unwarranted especially since there was no corresponding increase in bond strength between 60- and 120-sec etch times.

The mean bond strengths obtained for the 4 etch times were not significantly different. However, the standard deviations after 15- and 30-sec etching were somewhat larger than those seen at 60 and 120 sec. This would suggest that there was a greater variation in bond strengths for the 2 shorter etching periods than for the 2 longer etch times. A significant contribution to these large standard deviations is made by 1 or 2 very high bond strengths recorded after the shorter etching times. For instance, recalculating the mean of the bond strengths of the 30-sec etch group without including the 249 kg/cm^2 value (Table 1), thus erring on the conservative side, reduces the mean to 84.05 and the standard deviation to ± 50.45 which is similar to that for the 60- and 120-sec enamel etch. This would suggest that a 30-sec etch period would be sufficient to obtain satisfactory sealant retention. It must be noted that the teeth used for bond strength analysis were not prepared to a flat parallel surface prior to bond strength testing because the authors felt it important to leave the enamel as it existed in the oral environment. During the testing procedure some of the teeth became dislodged from the stone in which they were embedded; thus, their bond strengths could not be measured and they were excluded from the study. This accounts for the difference in sample sizes seen in Table 1 for the subgroups.

The sheared sealant enamel junctions were examined after fracture under SEM. These showed areas of remaining sealant on the enamel and no evidence that the fracture occurred solely at the junction. This observation could explain the similarities in bond strengths throughout the 4 subgroups.

The 3 types of etch patterns were seen on all the enamel surfaces irrespective of the etch time. However, there were also areas left unetched by the acid

in all subgroups. In fact, samples viewed without prior knowledge of their subgroupings were indistinguishable from each other. The etched occlusal surfaces showed no qualitative differences from the etch patterns observed on smooth surfaces. Further, the various etch times did not reveal any characteristic differences in sealant tag patterns when viewed by SEM.

It also should be noted that this was an *in vitro* study under relatively ideal conditions. Therefore, the problem of moisture control which may occur in the oral environment was not experienced.

Conclusion

The results of this study seem to indicate that a 120-sec etch on primary enamel does not increase the bond strength compared to 15-, 30-, or 60-sec etching. The larger standard deviations of the bond strength means for the 15- and 30-sec etch compared to etching for 60 or 120 sec suggests a greater bond strength variation and precludes, at this time, suggesting a reduction of etch time below 60 sec. Since the etch depth increases dramatically between 60 and 120 sec, and there is no corresponding improvement in the bond strength, it seems unnecessary to subject the enamel to the additional loss, or the dentist and the child to the additional time needed to complete a 120-sec etch. A clinical trial now is desirable to establish the efficacy of the proposed etching time.

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