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Effect of Varying Etching Times on the Tensile Bond Strength Of Primary Tooth: An In Vitro Study

* Dr. Aswathi R[1] , Dr. Vishnu Rekha Chamarthi[2], Dr. Dhanraj Kalaivanan[3], Dr. Santham Krishnamoorthy [4], Dr. Sumaiyya Saleem[5], Dr. Santhosh Priya A K R[6], Dr. Sai Sarath Kumar Kothimbakkam [7]

[1234567] Department of Pediatric and Preventive Dentistry. Sathyabama Dental College and Hopital,Chennai, Tamil Nadu, India.

[1] aswathiaravind2018@gmail.com

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Abstract

Background: Regarding the optimal time to etch primary dentin and how it affects the bond strength of adhesive restorative materials, there are contradictory findings.

Aim of the study: Evaluate the impact of various etching times on the primary dentin's tensile bond strength.

Materials and methods: Human primary molars that had been extracted or exfoliated and free of caries were split into buccal and lingual/palatal halves. Each sample was mounted on a 1 × 1 inch acrylic block. Samples were randomly assigned into 4 groups, each of which had 10 samples. 10% phosphoric acid was used to etch groups 1, 2, 3, and 4 for seven, ten, fifteen, and twenty seconds, respectively. After applying the bonding agent a composite resin rode was constructed on the demarcated, etched area of the tooth. Tensile bond strength was assessed using a universal testing machine. For intergroup comparison, an ANOVA test was performed. p value < 0.05 was set as statistically significant.

Results: Group 1, with an etching time of 7 seconds, showed the highest tensile strength, followed by Group 2 of 10 seconds, Group 3 of 15 seconds, and Group 4 of 20 seconds which was statistically significant with p value 0.01.

Conclusion: Reducing the acid etching time improves the primary dentin's tensile strength. Because of their limited cooperation, children benefit greatly from shorter etching time.

Keywords: Tensile bond strength, Etching, Primary tooth

Introduction

The development of adhesives and composite resins has expanded the clinical indications for tooth colored restorations. There are additional compelling reasons to use composite resins, such as more conservative cavity preparations and growing public interest about aesthetics. However, pediatric dentists continue to deal with the failure of these restorations in primary teeth. Composite resins perform worse over time when used for primary tooth restorations because primary teeth have a weaker bond than permanent teeth.[1] Primary and permanent dentin differ in their micromechanical and histological properties, which could affect the adhesion mechanism.[2] Primary teeth have peritubular dentine that is two to five times thicker than that of permanent teeth, and they have fewer and smaller dentinal tubules that are located between 0.4 and 0.5 mm from the pulpal surface. Furthermore, it has been demonstrated that the peritubular and intertubular dentine of primary teeth have lower concentration of calcium and phosphorous. [3]

An essential step in modifying the dentine surface to have enough adhesion and bond strength of composite resin is dentine conditioning or etching.[3] There are two goals for dentin etching. In order to reveal open dentinal tubules that can be filled with resin, it first removes the smear layer and debris created during tooth preparation. Second, the dentin layer is demineralized by the etchant, revealing the collagen fibers and allowing the resin to enter the dentin structure.[4] Different etching times with acidic conditioners result in different depths of demineralization.[2] Depth of dissolution depends on type and concentration of acid used and duration of etching.[3] Infiltration of bonding agent into demineralized dentine layer results into formation of a new layer, the hybrid layer (Nakabayasi 1982) or resin

dentine inter diffusion zone (Van Meerberk et al 1992-93)[3]. Hence, in order to obtain proper adhesion of composite resin, it is necessary to create hybrid layer at the interface between resin and dentine.[3] Using etching times of 7 and 15 seconds, a prior study examining the hybrid layer thickness in primary and permanent teeth found that the primary dentin had a noticeably thicker hybrid layer, indicating a high reactivity to acid etching. The lower bond strength values of primary dentin were attributed to the adhesive resin's inability to fully penetrate the thick hybrid layer.[5] The performance of composite resin restorations is therefore influenced by the effects of etching and the characteristics of the dentin substrate that are produced as a result.[5]

Furthermore, a demineralized layer that is too deep for the adhesive monomers to fully penetrate is produced by an aggressive etching pattern of the etchant that is currently most frequently used (30–40% phosphoric acid). Acid exposed collagen fibrils at the bottom of the hybrid layer become extremely vulnerable to degradation by endogenous, matrix-bound enzymes like MMPs. Phosphoric acid's low pH is also crucial for the activation of endogenous MMPs, which further contributes to the breakdown of collagen and, ultimately, the failure of the resin-dentin bond.[6]

Etching is a double-edged weapon. When done correctly, it can produce a strong bond as long as other procedures are carefully followed. However, if etching is done too aggressively, it will cause the tooth to weaken because excessive mineralized tissue will be lost.[4]

However, there are no well-established guidelines regarding how long to etch the primary dentin in order to strengthen the bond with adhesive materials.[5] Therefore, this in vitro study's objective was to evaluate how different etching times affected the tensile bond strength of primary dentin.

Materials and methods

Primary molars that were free of caries, visible defects, or fractures and that had been extracted or exfoliated as a result of preshedding mobility were included in the study. Teeth with hypoplastic conditions, white spot lesions, restorations, or prior etching treatments were not included.

Open Epi software was used to determine the sample size, which had a power of 80 and a confidence level of 95. A total of 40 samples were estimated and allocated to 4 groups of 10 samples in each.

Sample preparation

Primary molars sectioned at cementoenamel junction and roots discarded. crown sectioned longitudinally into buccal and lingual/palatal halves. Buccal or lingual / palatal surface was ground using a double faced diamond disc and water coolant until the dentin was exposed. Samples were mounted on an acrylic block measuring 1x1 inch with the buccal or lingual/palatal surface faced up. The exposed surfaces were sequentially wet grinded using silicon carbide paper with grits of 400 and 600 for 30 seconds.

The samples were randomly allocated into four groups of ten. Each sample was etched for the assigned period of time using 10% phosphoric acid.

Group 1 (n=10) - 7 seconds

Group 2 (n-10) - 10 seconds

Group 3 (n=10) - 15 seconds

Group 4 (n=10) - 20 seconds

The exposed tooth surface was covered with 3x3 adhesive tape, and the remaining tooth surface was coated with varnish. After removing the adhesive tape, the demarcated area was etched for the allotted period of time using 10% phosphoric acid. Etched surfaces were dried using blotting paper. 3M ESPE Adper Single Bond 2 adhesive was applied and allowed to cure for 20 seconds. Over the demarcated window, a 3 mm diameter and 2 mm height composite resin rod was made with 3M Filtek Z 350XT composite. To provide an attachment for the loop in the Universal testing machine (Instron 3366, USA), a 0.7 mm diameter wire that had been bent into a triangle shape was incorporated within the composite resin rod. All samples were left immersed in saline for 24 hours, and the universal testing machine was used to measure the tensile bond strength. The samples were loaded at a cross head speed of 1 mm per minute until the composite separated from the tooth.

Figure 1: Tooth sectioning

Figure 2: Sectioned tooth

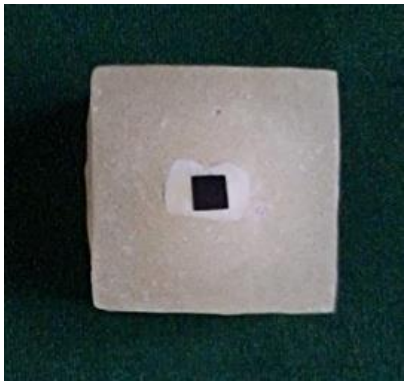


Figure 3: Adhesive tape affixed on exposed surface

Figure 4: composite rode with incorporated triangular shaped wire on prepared tooth surface

Figure 5: Sample placed in universal testing machine

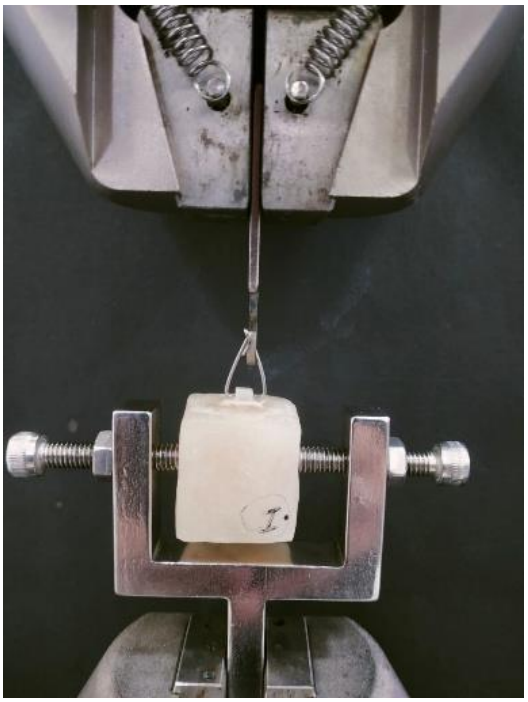


Figure 6: tensile strength testing with universal testing machine.

Statistical analysis

IBM SPSS Statistics 25 was used to conduct the statistical analysis. The mean tensile strength of the four study groups were compared using the ANOVA test.

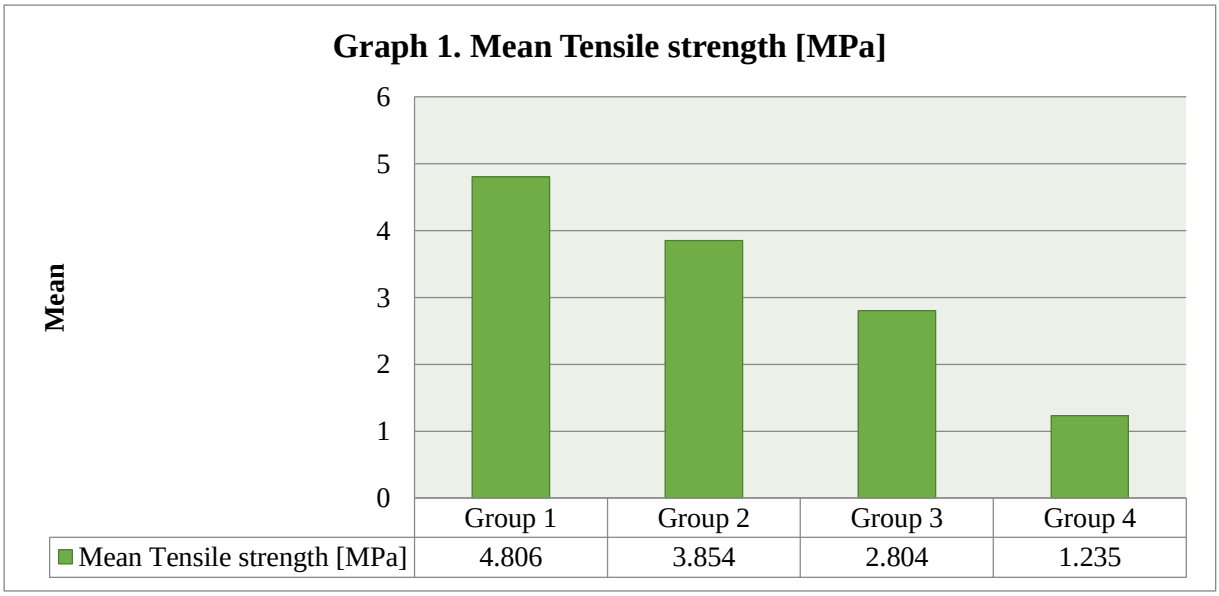
p value less than or equal to 0.05 was set as statistically significant.

Results

Table 1 and graph 1 demonstrate the mean tensile strength and standard deviation of 4 study groups. Group 1 with an etching time of 7 seconds, shows the highest tensile strength (mean tensile strength 4.806 MPa, SD 0.485), followed by Group 2 at 10 seconds (Mean tensile strength 3.854, SD 0.255), Group 3 at 15 seconds (Mean tensile strength 2.804, SD 0.231), and Group 4 at 20 seconds (Mean tensile strength 1.235, SD 0.376). The ANOVA test was done for intergroup comparison. The difference in mean tensile strength between the four study groups were statistically significant with p value 0.01. According to the results, 7 seconds is the ideal etching time to achieve the maximum tensile strength in primary dentin.

Specimen	Mean Tensile strength [MPa]	Standard deviation (SD)	P- value
Group 1(7S)	4.806	0.485	0.01*
Group 2 (10 S)	3.854	0.255	
Group 3 (15 S)	2.804	0.231	
Group 4 (20 S)	1.235	0.376	

Table 1. Comparison of mean tensile strength between the four study groups (ANOVA test)



Discussion

In this study, the impact of varying etching times on the tensile bond strength between primary teeth (dentine) and composite resin was assessed and compared. According to research by Gwinnet and Nor, 10% phosphoric acid adequately demineralizes the primary dentin surface and makes it receptive to adhesive restorations. For this reason, it was selected. [5] Applying acid to dentine removes the mineral component, exposing the collagen network (Van Meerbeek et al 1992). Strong acids cause excessive demineralization of intertubular and peritubular dentine in addition to completely removing the smear layer and smear plug (Erickson 1992). The bonding ability is subsequently compromised by this excessive demineralization, which results in the loss of tooth structure and the collapse of collagen meshwork that cannot be restored, not even with the use of hydrophilic primers.[3]

Smear layer removal is influenced by the acid's concentration and length of contact with the tooth surface. Long-term application of strong acids causes the peritubular and intertubular dentin to become excessively demineralized, which severely collapses the collagen mesh work.[5] The thicker hybrid layers and lower bond strength values found in primary dentin seem to be caused by the highest density and tubular diameter, as well as the lowest mineral content.[7] The complete penetration of resin monomers is hindered by thick demineralized dentin layers, particularly at their base. Over time, the hybrid layers with demineralized dentin zones that are either poorly or not infiltrated provide a pathway for nanoleakage and interface degradation. [7]

To achieve a uniform depth of dentin relative to the pulp chamber, labial surfaces were used in this study.[1] HEMA cannot penetrate deeply into the demineralized dentine if the etched dentine is over-dried to eliminate extra water after rinsing. This is because the collagen network may break down and the microchannels created by the removal of the apatite crystals may close. To avoid this, the present study

employed the concept of "Wet-bonding" (John Kanca III 1992).[3]

According to Sardella et al. reducing the duration and acid concentration used to etch primary dentin did not weaken the bond with restorative material.[8] In an in vitro investigation, Keerthana Satish et al. found that conditioning primary dentin with 37% phosphoric acid for 7 seconds resulted in more effective etching and contributed to a strong bond with adhesive restorative material.[5] In a systematic review and meta- analysis, Larissa D'Olanda Gindri et al. claimed that long-term bond strength of etch-and-rinse adhesive is enhanced by shortening the acid etching time to primary dentin.[7] A similar in vitro study by Carolina Paes Torres et al. found that the 7-second etching time promoted the highest bond strength, despite the fact that no statistically significant difference between the times used was found. [2] Stefanie Amend and colleagues investigated impact of 7-second phosphoric acid etching on the adherence of a 3-step etch-and-rinse adhesive to primary tooth dentine. They came to the conclusion that 7-second etching might enhance the immediate TBS of a 3-step ER adhesive. [9]

In this study we have assessed tensile bond strength of primary dentin to adhesive resin with 10% phosphoric acid as etchant at different etching period. This in vitro study considered only tensile bond strength and did not consider the normal masticatory load. Further study with different concentration of phosphoric acid considering the expected masticatory load is required for suggesting an ideal etchant concentration and etching time.

Conclusion

An etching time of 7 seconds provides the highest tensile strength, indicating it is the most effective duration for optimal surface preparation. The tensile strength of primary dentin is improved by shortening the acid etching duration.

The duration of the restorative treatment should be as short as possible because of the children's limited cooperation. When it comes to treating children, a shorter etching time means less chair time.

REFERENCES

1. Nor JE, Feigal RJ, Dennison JB, Edwards CA. Dentin bonding: SEM comparison of the dentin surface in primary and permanent teeth. Pediatr Dent. 1997;19(4):246-252.

2. Torres CP, Chinelatti MA, Gomes-Silva JM, Borsatto MC, Palma-Dibb RG. Tensile bond strength to primary dentin after different etching times. J Dent Child (Chic). 2007;74(2):113-117.

3. Shashikiran, N & Gunda, Sachin & Reddy, V. (2002). Comparison of Resin-Dentine interface in primary and permanent teeth for three different durations of dentine etching. Journal of the Indian Society of Pedodontics and Preventive Dentistry. 20. 124-31.

4. Katta, Prashanth. (2020). Etching in Dentistry. Indian Journal of Dental Education. 13. 17-20. 10.21088/ijde.0974.6099.13120.2.

5. Satish K, Nayak R, Ginjupalli K, Balagopal S. The effect of acid concentration and etch time on morphology and tensile bond strength of primary dentin: An in vitro study. J Indian Soc Pedod Prev Dent. 2021;39(3):267-274. doi:10.4103/jisppd.jisppd_141_21

6. Nisar S, Liu H, Hass V, Wang Y. Dual-functional etchants that simultaneously demineralize and stabilize dentin render collagen resistant to degradation for resin bonding. Dent Mater. 2023;39(11):1004-1012. doi:10.1016/j.dental.2023.09.002

7. Gindri LD, Fröhlich TT, Rosso CR, Rocha RO. Etching time and bonding of adhesive systems to dentin of primary teeth: A systematic review and meta-analysis. Int J Paediatr Dent. 2021;31(1):122-130. doi:10.1111/ipd.12711

8. Sardella TN, de Castro FL, Sanabe ME, Hebling J. Shortening of primary dentin etching time and its implication on bond strength. J Dent. 2005;33(5):355-362. doi:10.1016/j.jdent.2004.10.011

9. Amend S, Frankenberger R, Oschmann T, Lücker S, Winter J, Krämer N. Long-term microtensile bond strength of self-etch adhesives and influence of 7-s phosphoric acid etching on adhesion of a 3-step etch-and-rinse adhesive to the dentine of primary teeth. Int J Paediatr Dent. 2022;32(5):649-659. doi:10.1111/ipd.12943