Journal of Babol University of Medical Sciences
JBUMS
e-ISSN: 2251-7170 p-ISSN: 1561-4107

Comparison of the Push-Out Bond Strength of 5th, 6th, 7th and 8th Generation Bonding Agents to Intracanal Dentin of Primary Anterior Teeth

R. Meshki (DDS, MS)[1], M. Khataminia (DDS, MS)[1], S. Beigi (DDS, MS)[*1], M. Salehi Veisi (PhD)[2]

1.Department of Pediatric Dentistry, School of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, I.R.Iran.
2.Department of Statistics, Faculty of Basic Sciences, Behbahan Khatam Alanbia University of Technology, Behbahan, I.R.Iran.

Article Type
Research Paper

ABSTRACT

Background and Objective: Due to the importance of primary anterior teeth in chewing, pronunciation of words, self-confidence, facial appearance of children, efforts to preserve these teeth continue. The aim of the present study was to evaluate the push-out bond strength of 5th, 6th, 7th, and 8th generation bonding agents to intracanal dentin of primary anterior teeth which are reconstructed with the composite posts.

Methods: The present experimental in vitro study was conducted on 60 extracted primary anterior teeth with at least two-thirds of the root length remaining. The teeth were randomly divided into five groups: 5th generation (3M Adper single bond 2 Adhesive-USA), 6th generation (clearfil SE bond, Japan), 7th generation (kerr-optibond all in one Adhesive-Italy), and 8th generation total-etch and 8th generation self-etch (GC-G permio bond-Japan) bonding agents. After root canal preparation, prepared canals were filled with Metapex. The coronal 3mm of the canals was etched and impregnated with the dentin bonding agents. Then, they were restored with composite. The push-out test was performed to evaluate the bond strength of adhesives. Accordingly, by a light microscope the failure modes were determined.

Findings: The mean bond strength of 5th, 6th, 7th, and 8th generation (self-etch, total-etch) bonding agents was 4.36±2.15, 3.88±1.55, 4.29±2.02, 12.84±3.62, and 7.77±3.81 MPa, respectively. The push-out bond strength of the 8th generation bonding agent using both self-etch ($p=0.000$) and total-etch techniques was higher than the 5th, 6th, and 7th generation bonding agents ($p=0.032$, 0.01, 0.027, respectively). No significant difference was found between the bond strength of the 5th, 6th, and 7th generation bonding agents.

Conclusion: The push-out bond strength of the 8th generation bonding system was higher than the other groups. Therefore, the 8th generation bonding agents can be used to bond composite posts to intracanal dentin of primary anterior teeth. Also, self-etch (8th generation) has higher bond strength compared to the total-etch technique.

Received: Jan 27th 2022
Revised: May 10th 2022
Accepted: May 28th 2022

Keywords: *Dentin, Self-Etch Adhesive, Bonding Agents.*

Cite this article: Meshki R, Khataminia M, Beigi S, Salehi Veisi M. Comparison of the Push-Out Bond Strength of 5th, 6th, 7th and 8th Generation Bonding Agents to Intracanal Dentin of Primary Anterior Teeth. *Journal of Babol University of Medical Sciences*. 2023; 25(1): 26-35.

***Corresponding Author: S. Beigi (DDS, MS)**
Address: Department of Pediatric Dentistry, School of Dentistry, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, I.R.Iran.
Tel: +98 (61) 33112346. **E-mail:** beigi.s1373@gmail.com

[DOI: 10.22088/jbums.25.1.26]

Introduction

Early Childhood Caries (ECC) is the widespread chronic infectious disease of childhood that typically targets the maxillary incisors of the deciduous teeth. Early loss of these teeth in childhood causes problems such as tongue thrust, loss of vertical dimension of occlusion, impaired pronunciation of words, chewing difficulty, and social and personality development in children (1-4). Extraction of primary teeth was the traditional method of managing children with ECC. But with the advancement of materials, techniques, the introduction of adhesive restorations, bonding, and also increased awareness of parents, the demand for the maintenance and reconstruction of these teeth has increased (5-8).

Cosmetic restorations in these teeth are still a big challenge due to the smaller size of the tooth, thinness of the enamel and less surfaces for bonding, tubules in fewer numbers and larger diameter, greater thickness in peritubular dentin and less mineralization in intratubular dentin. Also, moral issues, children's age and cooperation, treatment costs, etc. are other problems in the restoration of these teeth (3, 9-12).

Successful dental caries management in pediatric patients and behavior management techniques require modern restorative techniques and high-quality restorative materials with the least amount of time. Ideal restorative materials are easily attached to the tooth and have mechanical properties, strength, sufficient abrasion resistance and insensitivity to moisture. It is also preferably done in one treatment session. The introduction of adhesive restorations was a major revolution in anterior teeth. Among the materials introduced now, composite resin adhesive restorations are the most common and common materials, which have good mechanical properties, low coefficient ratio of thermal expansion, and higher abrasion resistance than other adhesive materials (12-14).

The American Academy of Pediatric Dentistry (AAPD) suggests that strip crowns, pre-veneered stainless-steel crowns (SSC) and opened-face SSCs be used as treatment options for coronal coverage restorations in primary anterior teeth. The use of these veneers requires a sufficient amount of crown structure and is also limited due to gingivitis and pain and recurrent caries early in their use (9-11, 15). Therefore, restoring primary anterior teeth that affected deeper layers of teeth has been a great challenge for the pediatric dentist. After root canal therapy, dentists can restore crowns with intracanal posts. Composite resin posts are the most commonly used method for restoration of severely decayed primary anterior teeth which are bonded to intracanal dentine using dentin adhesives (3, 5, 8, 10).

The mechanism of action of bonding involves the hybridization of dentin and the formation of resin tags. Dental adhesive systems have developed from the 4th and 5th generations (etch and rinse) to the 6th, 7th, and 8th generations (self-etching system). The self-etching adhesive system has fewer clinical steps, so it can be helpful in pediatric dentistry (4, 13, 15, 16). Bonding to dentin is more difficult and less reliable due to dentine's biological structure and dentinal tubules (hydrophilic nature, smear layer, mineral nature of dentine, and Importance of material compatibility with pulp). The new bonding agents are hydrophilic and can bond well to dentin by forming a hybrid layer (4, 17). Bond strength of self-etch adhesive systems to enamel due to the lack of complete removal of smear layer is not good as in total-etch systems. However, self-etch bonding systems offer a less sensitive method to adhesion and require fewer steps in clinical practices (14). In total-etch adhesives, strong acids promote dentin demineralization. So, the monomers do not fully diffuse into the collagen network, which has a negative effect on the bonding uniformity. However, dentin and enamel are simultaneously primed and bonded into the exposed collagen network in self-etching generations and provide gap-free bonding between dentin and monomer (14, 18-22). There are different opinions in comparing total-etch and self-etch systems in deciduous teeth restoration.

[DOI: 10.22088/jbums.25.1.26]

The study by Stalin et al. showed no significant difference in tensile strength and microleakage in the application of 5th and 6th generation systems in deciduous teeth. Also, deciduous teeth showed lower bond strength and higher microleakage than permanent teeth. This difference is due to the different chemical and microbiological structures and primary and permanent dentition properties, such as fewer tubules with minor mineralization, less permeability, and greater reactivity to acid conditioning (18). However, in the study of Torres et al., it was found that total-etch systems provide the best bonding while self-etch systems have lower bond strength to deciduous teeth (20).

The new nano-adhesives have been introduced as one of the chief contributions of nano dentistry. Nano-adhesives contain soluble nanoparticles (nanofillers) that prevent agglomeration, easily apply to acidified enamel surfaces, and create bond strength. The main advantages of nano-adhesives are high-stress absorption, stable marginal seal, longer shelf life, and fluoride release. The 8th generation bonding agent has been shown to have highest shear bond strength compared to the previous generations (4, 23, 24).

The bonding effectiveness of the total-etch and self-etch adhesive in deciduous teeth is still a challenge. Despite numerous studies on the range of adhesives in crown-to-dentin bonding in primary and permanent dentition, the studies available to investigate bonding in bond strength of intra-channel posts are limited. Since no studies have been evaluated the push-out bond strength of the 8th generation bonding system to intracanal dentin of primary anterior teeth, the present study compared the push-out bond strength of the 8th generation bonding system using total-etch, and self-etch techniques with 5th, 6th, and 7th generation bonding agents to intracanal dentin of primary anterior teeth.

Methods

After being approved by the ethics committee of Jundishapur University of Medical Sciences, Ahvaz with the code IR.AJUMS.REC.1399.923, this in vitro study was conducted on 60 maxillary primary anterior teeth extracted due to severe caries, with at least two thirds of their root length remaining. The teeth were kept for one week in 0.5% chloramine T solution (Merck KGaA, Darmstadt, Germany) and then in distilled water solution (Shahid Ghazi Co, Tabriz, Iran) (3). The crown of the teeth was cut 1 mm above the CEJ using a diamond disc perpendicular to the longitudinal axis of the tooth. According to the study by Afshar et al. (3), the minimum sample size in each group for $\alpha=0.05$ and $\beta=0.02$, and the mean difference of 3.3 and standard deviation of 3.16 was 12 teeth in each group, and these 60 teeth were randomly divided into five groups.

5th generation bonding agent (3M Adper single bond 2 Adhesive-USA), 6th generation bonding agent (clearfil SE bond, Japan), 7th generation bonding agent (kerr-optibond all in one Adhesive-Italy) and 8th generation bonding agent were used based on total-etch and self-etch methods (GC-G permio bond-Japan) in groups 1, 2, 3, 4 and 5 (8th generation bonding by total-etch and self-etch methods in two separate groups), respectively, according to the manufacturer's instructions.

Root canals were prepared using K files (Mani Inc., Tochigi, Japan). The root canals were irrigated with saline solution and dried with paper points (#50) (Gapadent, China), and obturated with Metapex (Meta Biomed Co., Ltd, Korea). Then the coronal 3 mm of root canals were removed, and a thin layer (1 mm) of light-cured glass ionomer cement (Glass Ionomer Universal Restorative, GC Corp. Tokyo, Japan) was applied over Metapex and light-cured for the 20s using light-curing unit (Woodpecker LED Light Cure Unit, China). The coronal 3mm of the root canals were etched for 15 seconds using 37% phosphoric acid (Vericam, Denfill, Korea), and were impregnated with dentin bonding agent using a sterilized micro brush, then gently air-dried and cured according to manufacturer instructions. Finally, the canals were filled with composite resin (Filtek Silorane, 3M ESPE, USA) and cured using the incremental technique (20s per layer).

[DOI: 10.22088/jbums.25.1.26]

Specimens were cured under similar conditions using a LED light-curing unit with a light intensity of 350 MW/cm^2 and curing tip distances of 2mm. Teeth samples were then mounted in acrylic blocks and stored in distilled water at 37°C until push-out shear bond strength testing. A 1mm thick section was created at the settled site via a water-cooled diamond blade on Mecatome cutting machine (Perci, T201A, France). A universal testing machine (Zwick/Roell Z05, Ulm, Germany) measured the push-out bond strength.

The force was applied to the bonding interface in an apico-cervical direction by stainless steel cylindrical plunger proportional to the canal diameter at a crosshead speed of 0.5 mm/min. The bond strength was recorded in Megapascal (MPa), and the highest load (failure point) was recorded in Newton (N) by division of failure point to cross-sectional area (mm^2). Before the push-out shear bond strength test, the original photograph was taken from both sides of each section using a professional camera (Canon, Eos600D, Japan). The pictures were imported into AutoCAD software (version 2013). The cross-sectional area was computed using the (A1+A2) h/2 formula (A1= circumference of one side of the root canal ($2\pi r_1$), A2= circumference of the other side of root canal ($2\pi r_2$), H= the height (mm) of the prepared section). The modes of failure (adhesive, cohesive, mixed) were analyzed using a stereomicroscope (Olympus, Tokyo, Japan) at 40× magnification. Statistical analysis of the push-out bond strength among the studied bonding agents was performed using One-way ANOVA (analysis of variance) with a post-hoc Tukey HSD (Honestly Significant Difference) test. P-value less than 0.05 ($p\leq0.05$) was considered statistically significant.

Results

The mean bond strength of 5th, 6th, 7th, and 8th generation (self-etch, total-etch) bonding agents were 4.36±2.15, 3.88±1.55, 4.29±2.02, 12.84±3.62, and 7.77±3.81 MPa, respectively, which was acceptable in all study groups (Table 1).

The push-out bond strength of the 8th generation bonding agent using both self-etch (p=0.0001) and total-etch techniques was higher than the 5th, 6th, and 7th generation bonding agents (p=0.032, 0.01, 0.027, respectively). No significant difference was found between the bond strength of the 5th, 6th, and 7th generation bonding agents. The mean push-out bond strength of the 8th generation bonding agent using self-etch techniques was significantly higher than the total-etch technique (Tables 1, Figure 1).

Table 1. Descriptive analysis and comparison of bond strength of different bonding agents

Type of Bonding	Number	Mean±SD	Std. Error	95% Confidence Interval for Mean	Minimum	Maximum
5th generation	12	4.36±2.153[a]	0.621	2.995-5.731	1.69	8.11
6th generation	12	3.88±1.549[a]	0.447	2.896-4.865	0.94	6.46
7th generation	12	4.29±2.023[a]	0.584	3.006-5.578	0.935	7.11
8th generation self-etch	12	12.84±3.617[c]	1.044	10.543-15.141	7.25	19.14
8th generation total-etch	12	7.77±3.810[b]	1.099	5.351-10.193	1.78	12.56
total	60	6.63±4.362	0.563	5.503-7.757	0.93	19.14

[DOI: 10.22088/jbums.25.1.26]

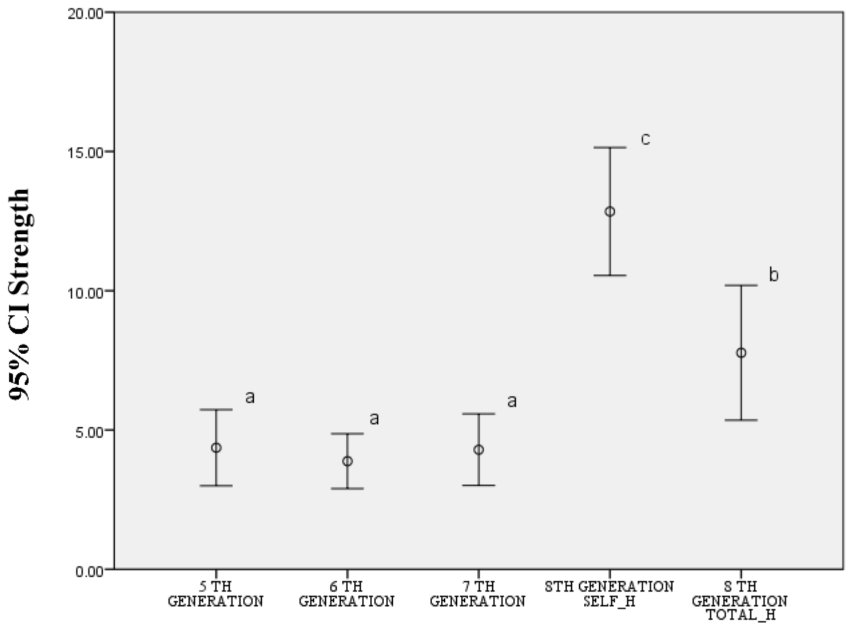

Figure 1. Comparison of composite bond strength to intracanal dentin in primary anterior teeth using 5th, 6th, 7th, and 8th generation bonding agents

Post hoc and Tukey's HSD tests were applied to evaluate the difference in the mean bond strength of the studied groups .The difference in the mean identical letters in the same column did not differ by Tukey's test at the alpha value of 0.05 (Table 1, Figure 1).

SIXTH GENER[a]< SEVENTH GENER[a]< FIFTH GENER[a]< EIGHTTH GENER TOTAL H[b]< EIGHTTH GENER SELF H[c]

Moreover, the types of failure (cohesive, adhesive, mixed) and their percentages are shown in Table 2 and Figure 2. Adhesive failure at the place of the composite to dentin bond, cohesive failure in the material itself (cohesive composite or cohesive dentin) and mix failure are defined as adhesive and cohesive failure at the same time. The results show a significant difference between 5th, 6th, 7th, and 8th generation bonding agents and the mode of failure depends on the generations of bonding used; in two-step self-etch bonding, 91.7% and in one-step self-etch bonding, 75% of the failures were mixed. However, in the 8th generation self-etch and total-etch bonding, 100% and 83.3% of the failures were of the cohesive composite type, respectively. Moreover, most variation in the mode of failure was observed in the 5th generation bonding (Table 2 and Figure 2).

Table 2. The bond failure modes of intracanal posts (Adhesive, Mixed, Cohesive within the composite, Cohesive within the dentine) and percentages

Type of Bonding	Adhesive Number(%)	Mixed Number(%)	Cohesive Dentin Number(%)	Cohesive Composite Number(%)
Fifth generation	2(16.7)	2(16.7)	1(8.3)	7(58.3)
Sixth generation	1(8.3)	11(91.7)	0(0)	0(0)
Seventh generation	1(8.3)	9(75)	0(0)	2(16.7)
Eighth generation- Self-etch	0(0)	0(0)	0(0)	12(100)
Eighth generation- Total-etch	0(0)	2(16.7)	0(0)	10(83.3)

[DOI: 10.22088/jbums.25.1.26]

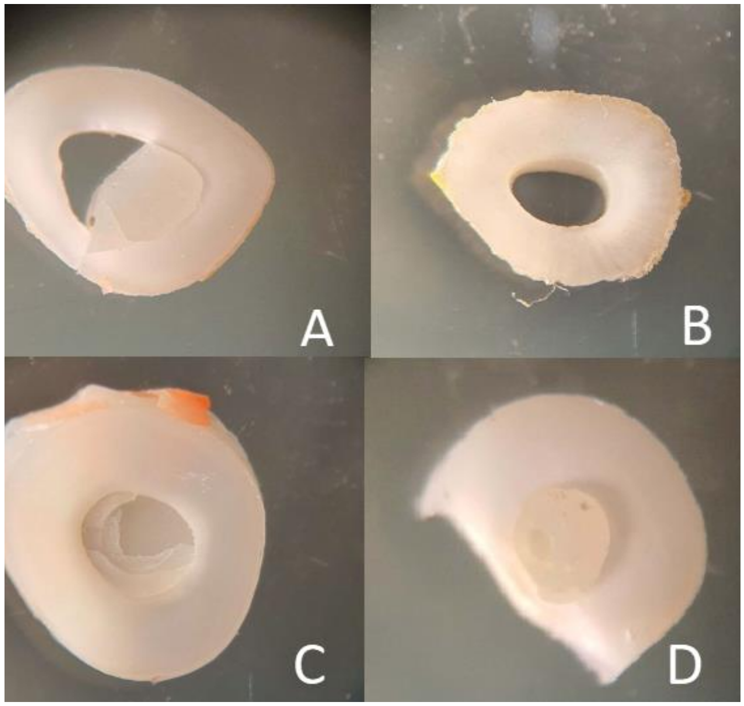

Figure 2. mode of failure, A: Mix, B: Adhesive, C: Cohesive within the composite, D: Cohesive within the Dentin.

Discussion

Based on the results of this study, the push-out bond strength of 8th generation bonding to the dentin inside the canal of primary anterior teeth was significantly higher than other groups. Similar results of tensile and shear bond strength of these bondings in crown restorations of deciduous and permanent teeth were seen in other studies (4, 24, 23). But so far, a similar study has not been done to check the push-out bond strength of these bondings by total-etch and self-etch methods to the dentin inside the canal of primary teeth. In cases of extensive coronal destruction, the use of posts inside the canal is necessary to provide sufficient grip and stability. These posts are used after pulpectomy treatment and the most common ones are composite posts (25-27). The clinical success of composite restorations depends on the adhesive system and their ability to create a strong bond between the composite and dentin (21). The push out bond strength test imposes a shear load on the bond between composite and dentin. This test is more similar to the clinical setting than the linear shear test (28).

Numerous factors influence the dentin bond strength during adhesive restorations, including the teeth type, mineralization of dentin, bonding areas of dentin, type of bond strength test, and relative humidity during clinical practice. Likewise, the pH scale range (acidity or alkalinity), type of solvent (aqueous ethanol or acetone), and filler percentage affect the dentin bond strength (3, 21).

There are some morphological differences between the bonds of total-etch and self-etch systems, including the hybrid layer's thickness. The total-etch bonding agents exhibit a thick hybrid layer than self-etching systems. However, the bond strength of the two systems has yielded controversial outcomes. The reason might be explained because the thickness of the hybrid layer does not play a significant role in the success of bond strength. In fact, the bond strength of dentine is mainly associated with the hybrid bond of resin tags interlocking with collagen fibers and the quality of the hybrid layer (29, 30).

[DOI: 10.22088/jbums.25.1.26]

In the present study, all the studied bonding agents (5th, 6th, 7th, and 8th generations) revealed adequate push-out bond strength to intracanal dentin of primary anterior teeth, and no significant difference was found among the push-out bond strength of the 5th, 6th, and 7th generation bonding agents. In a study by Afshar et al. no significant difference was found between the push-out bond strength of the 5th, 6th, and 7th generation bonding agents (3). Sachdeva et al. found no significant difference in the shear bond strength of 5th, 6th, and 7th generation bonding systems (4). A study by Donmez et al. found no significant difference in the clinical bonding performance of the 5th, 6th, and 7th generation adhesive systems (13). Joseph et al. and Kamble et al. also reported no significant difference in the micro tensile bond strength of 6th and 7th generation bonding agents (23, 24).

Yaseen et al. evaluated the shear bond strength of 6th and 7th generation adhesive systems to primary dentin. They found no significant difference between different bonding systems. However, the bond strength value in the study of Yaseen et al. was higher than the present study, which can be linked to the morphological difference in bonding at different areas of the tooth and different tubule sizes of areas; the dentin is farther away from the pulp, is more calcified, and shows more bond strength (due to the difference in the diameter of the tubules in different areas of the tooth) (21). Stalin et al. showed no statistically significant difference between the tensile-bond strength of fifth and sixth generation adhesive systems in the primary dentition (18). However, Torres et al. suggested that total-etch adhesives can produce higher bond strengths and overall bonding performance to primary dentin than self-etch adhesives, and they attributed their results to the incomplete removal of the smear layer and penetration of bonding in the self-etch adhesives (20). In self-etching adhesives, dentin and enamel are primed and bonded into the exposed collagen network, providing gap-free bonding between dentin and monomer. This could reinforce the bond strength of the self-etching adhesive system. The strong acidic primer provides a gap between dentin and monomer in total-etch, negatively affecting the bond strength. The pH values and acidity of adhesive systems are factors affecting the bond strength (21, 30, 31). Self-etching primer adhesives perform better for bonding to dentin than total-etch systems due to hypersensitivity of dentine to acid decalcification (less mineralized) (13-16). However, total-etch adhesives are preferred for bonding to enamel owing to the highly mineralized crystalline structure of enamel and complete removal of the smear layer (14, 32).

The present study compared the push-out bond strength of the 8th generation adhesive system with the 5th, 6th, and 7th generation adhesive systems. The study results revealed that the push-out bond strength of the 8th generation bonding agent using self-etch and total-etch techniques was more than the 5th, 6th, and 7th generation bonding agents. The 8th generation adhesive systems can be used for direct and indirect restorations using self-etch and total-etch techniques. Sachdeva et al. found that the highest shear bond strength to dentin in the crown restoration of primary teeth was found in 8th generation bonding agents compared to 5th, 6th, and 7th generation bonding agents (4). Joseph et al. and Kamble et al. suggested that the tensile bond strength of the 8th generation dentine adhesive with a crown of primary teeth was significantly higher the 6th and 7th generation dentin bonding agents (23, 24).

The present study also showed that the mean push-out bond strength of the 8th generation bonding agent using self-etch techniques was significantly higher than the total-etch technique. In a study by Ryu et al., the application mode (self-etch and total-etch techniques) did not influence the shear bond strength of crown restoration on primary teeth with 8th generation and suggested that 8th generation bonding agent can be used successfully in primary teeth without separative phosphoric acid etching (33). The reason can be related to the chemical composition of enamel and dentin. To address this issue, the high dentin bond strength in the self-etch system is associated with the least microleakage in dentin margins and prevention of over-drying, followed by etching of the dentin. Therefore, because of dentine hypersensitivity to decalcification (less mineralized), self-etch adhesives are preferred for bonding to dentin. However, total-etch adhesives exhibit higher bond strength values to enamel due to enamel's highly mineralized crystalline structure and complete removal of the smear layer. Furthermore, the low-level pH and discrepancy between the depth of dentin demineralization and monomer infiltration in total-etch adhesives explicate the high dentin bond strength in self-etch adhesives (14).

Pattern and mode of failure varied according to the nature and fabrication of the bonding agent. The most common failure modes of self-etch bonding agents in primary teeth are adhesive and mixed failures (34). Afshar et al. found a significant difference in the failure modes of the total-etch and two-step self-etch systems (3). However, Shimada et al. found no difference between the adhesive systems (35).

Based on the results of our study, the failure pattern mostly relied on the specific type of bonding system. In this study, the failure modes of two-step self-etch adhesives were mostly mixed failure (91%), indicating the formation of a homogenous hybrid layer and better distribution of stress in the adhesive area (36). The 5th generation bonding agent revealed different failure modes compared to other studied bonding agents, which can be attributed to the higher technical sensitivity of the 5th generation bonding agent (3). The failure mode in the 8th generation bonding agent was mostly cohesive failure (self-etch=100%, total-etch=83.3%), indicating the strength of the bonding system in the composite-dentine interface.

The push-out bond strength of the 8th generation bonding system was higher than the 5th, 6th, and 7th generation bonding systems. Therefore, the 8th generation bonding agents can be used to bond composite posts to intracanal dentin of primary anterior teeth. Self-etch (8th generation) with a higher push-out bond strength and fewer clinical steps than the total-etch (8th generation) technique. So, it can be useful in pediatric dentistry.

Funding/Support: None.

Conflict of interest: Authors have no conflict of interest.

Acknowledgment

We would like to thank all the members of the study team, the staff of the clinic and the faculty members of the Department of Pediatric Dentistry, Ahvaz Jundishapur University of Medical Sciences, for their cooperation in preparing the article.

[DOI: 10.22088/jbums.25.1.26]

References

1. Ribeiro JF, Forgerini TV, Pedrotti D, Rocha RO, Ardenghi TM, Soares FZM, et al. Performance of resin composite restorations in the primary dentition: a retrospective university-based study. Int J Paediatr Dent. 2018;28(5):497-503.
2. Aminabadi NA, Mostofi Zadeh Farahani R. The efficacy of a modified omega wire extension for the treatment of severely damaged primary anterior teeth. J Clin Pediatr Dent. 2009;33(4):283-8.
3. Afshar H, Nakhjavani YB, Taban SR, Baniameri Z, Nahvi A. Bond Strength of 5(th), 6(th) and 7(th) Generation Bonding Agents to Intracanal Dentin of Primary Teeth. J Dent (Tehran). 2015;12(2):90-8.
4. Sachdeva B, Dua P, Mangla R, Kaur H, Rana S, Butail A. Bonding efficacy of 5th, 6th, 7th & 8th generation bonding agents on primary teeth. IOSR J Dent Med Sci. 2018;17(3):61-6.
5. Mosharrafian S, Afshar H, Farbod M, Baniameri Z. Effect of etching time and preparation on push-out bond strength of composite to intracanal dentin of primary anterior teeth. J Dent (Tehran). 2016;13(5):349-56.
6. Duhan H, Pandit IK, Srivastava N, Gugnani N, Gupta M, Kochhar GK. Clinical comparison of various esthetic restorative options for coronal build-up of primary anterior teeth. Dent Res J (Isfahan). 2015;12(6):574-80.
7. Paryab M, Afshar H, Seraj B, Shakibapoor S, Kharazifard MJ. Fracture strength of severely damaged primary anterior teeth after restoration with composite resin and resin-modified glass ionomer cement. J Iran Dent Assoc. 2016;28(2):57-63.
8. Seraj B, Ghadimi S, Estaki Z, Fatemi M. Fracture resistance of three different posts in restoration of severely damaged primary anterior teeth: An in vitro study. Dent Res J (Isfahan). 2015;12(4):372-8.
9. Sharaf AA. The application of fiber core posts in restoring badly destroyed primary incisors. J Clin Pediatr Dent. 2002;26(3):217-24.
10. Muhamad AH, Nezar W, Azzaldeen A, Hanali AS. Anterior dental esthetics in primary teeth. Int J Public Health Res. 2015;3(1):25-36.
11. Ajami BA, Ebrahimi M, Makarem A, Movahhed T, Motamedi AR. Evaluation of Survival Time of Tooth Color Dental Materials in Primary Anterior Teeth. J Dent Mater Tech. 2012;1(1):11-8.
12. Aminabadi NA, Najafpour E, Erfanparast L, Samiei M, Haghifar M, Deljavan AS, et al. Class III restoration of anterior primary teeth: in vitro retention comparison of conventional, modified and air-abrasion treated preparations. J Dent Res Dent Clin Dent Prospects. 2014;8(2):89-94.
13. Donmez SB, Turgut MD, Uysal S, Ozdemir P, Tekcicek M, Zimmerli B, et al. Randomized clinical trial of composite restorations in primary teeth: effect of adhesive system after three years. Biomed Res Int. 2016;2016:5409392.
14. Sundfeld RH, Scatolin RS, Oliveira FG, Machado LS, Alexandre RS, Sundefeld ML. One-year clinical evaluation of composite restorations in posterior teeth: effect of adhesive systems. Oper Dent. 2012;37(6):E1-8.
15. Atash R, Shayegan A, Poureslami H, Sharifi H, Shadman N. Effect of Thermocycling on Microleakage of New Adhesive Systems on Primary Teeth: An In-Vitro Study. J Dent Mater Tech. 2013;2(4):109-13.
16. Atash R, Van den Abbeele A. Bond strengths of eight contemporary adhesives to enamel and to dentine: an in vitro study on bovine primary teeth. Int J Paediatr Dent. 2005;15(4):264-73.
17. de Araujo FB, García-Godoy F, Issáo M. A comparison of three resin bonding agents to primary tooth dentin. Pediatr Dent. 1997;19(4):253-7.
18. Stalin A, Varma BR, Jayanthi. Comparative evaluation of tensile-bond strength, fracture mode and microleakage of fifth, and sixth generation adhesive systems in primary dentition. J Indian Soc Pedod Prev Dent. 2005;23(2):83-8.
19. Susin AH, Vasconcellos WA, Saad JR, Oliveira Junior OB. Tensile bond strength of self-etching versus total-etching adhesive systems under different dentinal substrate conditions. Braz Oral Res. 2007;21(1):81-6.

[DOI: 10.22088/jbums.25.1.26]

20.Torres CP, Corona SA, Ramos RP, Palma-Dibb RG, Borsatto MC. Bond strength of self-etching primer and total-etch adhesive systems to primary dentin. J Dent Child (Chic). 2004;71(2):131-4.
21.Yaseen SM, Subba Reddy VV. Comparative evaluation of shear bond strength of two self-etching adhesives (sixth and seventh generation) on dentin of primary and permanent teeth: An in vitro study. J Indian Soc Pedod Prev Dent. 2009;27(1):33-8.
22.Casagrande L, De Hipólito V, De Góes MF, de Araujo FB. Bond strength and interfacial morphology of two adhesive systems to deciduous dentin: in vitro study. J Clin Pediatr Dent. 2005;29(4):317-22.
23.Joseph P, Yadav C, Satheesh K, Rahna R. Comparative evaluation of the bonding efficacy of sixth, seventh and eighth generation bonding agents: an in vitro study. Int Res J Pharm. 2013;4(9):143-7.
24.Kamble SS, Kandasamy B, Thillaigovindan R, Goyal NK, Talukdar P, Seal M. In vitro Comparative Evaluation of Tensile Bond Strength of 6(th), 7(th) and 8(th) Generation Dentin Bonding Agents. J Int Oral Health. 2015;7(5):41-3.
25.Dogan S, Ozturk G, Gumus H. Treatment of Severely Decayed Anterior Primary Teeth with Short-Post Technique (Mushroom Restorations) Under General Anesthesia. Niger J Clin Pract. 2020;23(6):798-804.
26.Amaral RC, Ferreira IA, Campello SC, Calvo AF, Tedesco TK, Imparato JC. Use of intrarradicular pins in primary teeth: case report of one year of accompanying. RGO-Rev Gaúch. Odontol. 2019;67:e20190041.
27.Srinivas NC, Jayanthi M. Post endodontic restoration of severely decayed primary dentition: a challenge to pediatric dental surgeon. World J Dent. 2011;2(1):67-9.
28.Kahnamouei MA, Mohammadi N, Navimipour EJ, Shakerifar M. Push-out bond strength of quartz fibre posts to root canal dentin using total-etch and self-adhesive resin cements. Med Oral Patol Oral Cir Bucal. 2012;17(2):e337-44.
29.Albaladejo A, Osorio R, Toledano M, Ferrari M. Hybrid layers of etch-and-rinse versus self-etching adhesive systems. Med Oral Patol Oral Cir Bucal. 2010;15(1):e112-8.
30.Sakaguchi RL, Powers JM. Craig's restorative dental materials, 13rd ed. Elsevier; 2012. p. 329-33.
31.Uekusa S, Yamaguchi K, Miyazaki M, Tsubota K, Kurokawa H, Hosoya Y. Bonding efficacy of single-step self-etch systems to sound primary and permanent tooth dentin. Oper Dent. 2006;31(5):569-76.
32.Oskoee PA, Navimipour EJ, Oskoee SS, Bahari M, Pournaghiazar F. Effect of different adhesion strategies on push-out bond strength of fiber reinforced composite posts. Afr J Biotechnol. 2011;10(76):17593-8.
33.Ryu W, Park H, Lee J, Seo H. Influence of Application Method on Shear Bond Strength and Microleakage of Newly Developed 8th Generation Adhesive in Primary Teeth. J Korean Acad Pediatr Dent. 2019;46(2):165-72.
34.Agostini FG, Kaaden C, Powers J. Bond strength of self-etching primers to enamel and dentin of primary teeth. Pediatr Dent. 2001;23(6):481-6.
35.Shimada Y, Senawongse P, Harnirattisai C, Burrow MF, Nakaoki Y, Tagami J. Bond strength of two adhesive systems to primary and permanent enamel. Oper Dent. 2002;27(4):403-9.
36.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):355-62.

[DOI: 10.22088/jbums.25.1.26]