Original Article

Effect of Adhesive Application on Sealant Success: A Clinical Study of Fifth and Seventh Generation Adhesive Systems

Vaibhav Tandon[1], Ravishanakar Telgi Lingesha[2]✉, Pradeep Shankar Tangade[2], Amit Tirth[3], Sumit Kumar Pal[3], Chaitra Telgi Lingesha[4], Vikram Arora[5], Vipul Yadav[6]

[1]Senior Lecturer, Department of Public Health Dentistry, Kothiwal Dental College & Research Center, Moradabad, India
[2]Professor, Department of Public Health Dentistry, Kothiwal Dental College & Research Center, Moradabad, India
[3]Reader, Department of Public Health Dentistry, Kothiwal Dental College & Research Centre, Moradabad, India
[4]Reader, Department of Pedodontics & Preventive Dentistry, Kothiwal Dental College & Research Centre, Moradabad, India
[5]Senior Lecturer, Department of Public Health Dentistry Swami Devi Dayal Dental College, Panchkula, India
[6]Senior Resident, Department of Public Health Dentistry, Maulana Azad Institute of Dental Sciences, New Delhi, India

Abstract

Objectives: The aim of the study was to compare the effect of fifth and seventh generation bonding agent on sealant success.

Materials and Methods: Sixty-four school children aged six to nine years received sealants in four permanent molars in a split mouth design, such that each patient received sealant in the first permanent molar with fifth generation bonding agent in one arch and seventh generation bonding agent in the other arch; contra-lateral molars were sealed with sealant alone. The evaluation was carried out at baseline, three months, six months and 12 months, according to the criteria by Feigal et al, in 2000. Chi- square test was used to analyze data at $P<0.05$ level of significance.

Results: Statistically significant differences were found for sealant retention between fifth generation and sealant group, and fifth generation and seventh generation groups; whereas, no significant difference was found for sealant retention between seventh generation and sealant group at three, six and 12 months.

Conclusion: As separate etch and rinse steps are not required for seventh generation bonding agents, and almost similar results were obtained for both sealant and seventh generation groups, it can be concluded that application of sealant along with a seventh generation bonding agent may enhance sealant success and can be used for caries prevention in preventive programs.

Key words: Pit and Fissure Sealants; Dental Caries; Adhesives

(Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2015; Vol. 12, No. 10)

✉Corresponding author:
R. Telgi Lingesha, Department of Public Health Dentistry, Kothiwal Dental College & Research Center, Uttar Pradesh, India

telgiravi@yahoo.com

Received: 16 March 2015
Accepted: 27 August 2015

INTRODUCTION

Dental caries is the most common chronic disease in humans [1]. The World Health Organization reports the prevalence of caries in school-aged children to be 60–90% [2]. Of all caries in children, 75% occur in pits and fissures [3,4].

Pit and fissure sealants are among the promising preventive methods to minimize occlusal caries [5]. The cariostatic properties

of sealants are due to the physical impediment of pits and fissures. Fissure sealants were first introduced in 1967 by Cueto and Buonocore [6] and their effectiveness was recognized by the American Dental Association in 1971 [7].

The anticipated function of a pit and fissure sealant is attained by the adherence of the sealant to the acid etched surface, and prevention of food impaction and colonization of bacteria. As long as the sealant remains intact, the changes of caries development beneath it will be minimal [8].

To date, nearly 50 years have passed since the introduction of pit and fissure sealants to the dental market, but the application of sealants is not as high as expected. This is probably due to the high failure rate of sealants due to inadvertent moisture or salivary contamination. The most common reason for sealant failure is salivary contamination of etched surface [9]. Since control of moisture in the oral cavity is difficult to achieve, placement of hydrophilic resin which is not sensitive to moisture may increase sealant retention. The first evidence of improved bond strength of etched enamel to sealant following the application of dentine bonding agents in presence of moisture or salivary contamination of enamel was reported by Hitt and Feigal in 1992 [10]. Other studies confirmed the advantages of bonding agents applied under sealants on the contaminated enamel to increase bond strength [11], reduce microleakage [12] and enhance the flow of resin into fissures [13].

Sealants were traditionally placed using a fifth generation adhesive system (applied in two steps of etching followed by adhesive application).

As multiple steps were required for the application of fifth generation bonding agents, it would increase chair side time, patient discomfort and risk of salivary contamination. To minimize these drawbacks, seventh generation bonding agents were introduced, which were applied in one step, (having etchant primer and adhesive in a single dispenser) known as self-etching bonding agents.

Seventh generation bonding agents, introduced in the early 2000s, contain acidic primers and adhesive monomers in a single bottle, eliminating acid-etching and rinsing steps and thus minimizing the time required for isolation and ensuring successful bonding [14]. As only a few studies have compared clinical sealant success after the application of different bonding agents, the aim of this study was to compare the effect of fifth and seventh generation bonding agents on sealant success.

MATERIALS AND METHODS

Based on the results of a previous study, a sample size of 60 children was estimated with α error=5%, β error=20%, 95% confidence interval and 80% power [13]. Due to the longitudinal nature of the study, anticipating the possible dropouts, a sample of 64 school children was recruited. All children between six-nine years, who fulfilled the inclusion and exclusion criteria were selected. The inclusion criteria were: Fully erupted bilateral permanent first molar teeth and deep occlusal fissures in molar teeth. The exclusion criteria were: Subjects with one carious or restored molar tooth in either side, molar teeth with their antagonistic teeth missing, uncooperative patients or handicapped patients. Written informed consent was obtained from the parents or legal guardians of all children and the study protocol was approved by the Institutional Ethics Review Committee of Moradabad.

Before starting the evaluation, the examiner was calibrated for recording marginal integrity, marginal discoloration, and anatomical form and kappa co-efficient for intra-examiner reliability ranged between 0.80 - 0.90.

Each of the 64 children received sealants in four permanent molars in a split mouth design, such that each child received sealant in a

permanent first molar with fifth generation bonding agent (Prime and Bond NT, DENSTPLY) in one arch and seventh generation bonding agent (Xeno V, Dentsply, Konstanz, Germany) in the other arch, and contra-lateral molars were sealed with sealant alone (Delton FS, Dentsply, Konstanz, Germany).

Sealant was placed in such a manner that out of 256 teeth, sealant along with fifth generation bonding agent was placed on 64 teeth i.e., 16 maxillary right molars, 16 maxillary left molars, 16 mandibular right molars and 16 mandibular left molars. Similarly, 64 teeth were sealed with sealant along with seventh generation bonding agent and the remaining 128 contra-lateral teeth were sealed with sealant alone (split mouth design).

The technique used for teeth sealed with sealant alone was as follows: the slow-speed, dry-brush cleaning of the surface; moisture control using cotton rolls and salivary ejector; 30 seconds of acid etching (37% H_3PO_4 gel); washing with air-water spray for 20 seconds; air-drying and finally placement of sealant followed by 40 seconds of light polymerization. Whereas technique used for teeth sealed with sealant along with fifth generation bonding agent was as follows: After etching and drying, a layer of fifth generation bonding agent was applied to the surface with a hand-held brush; this layer was then air-thinned and sealant was applied followed by 40 seconds of light polymerization.

Technique used for teeth which are sealed with sealant along with seventh generation bonding agent was as follows: after cleaning of the surface, moisture control was done using cotton rolls and salivary ejector; a layer of seventh generation bonding agent was applied to the surface with a hand-held brush; this layer was then air-thinned and sealant was applied followed by 40 seconds of light polymerization.

Adjustment of the occlusion was done with a micromotor headpiece and finishing burs. Sealant retention was checked with the help of an explorer. The evaluation was carried out at baseline, three months, six months and 12 months according to the criteria given by Feigal et al, in 2000 [15].

Parents were verbally reminded via phone calls about the next follow up and instructions were given to all the study subjects for the maintenance of oral hygiene.

Statistical analysis was carried out using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA) and the data were analyzed by Chi-square test at $P<0.05$ level of significance.

RESULTS

A total of 64 children who fulfilled the inclusion and exclusion criteria were recruited in the study. Dropouts were three, five and three children at three, six and 12 months, respectively. Out of 64 school children, 38 were males and 28 were females; there was no statistically significant difference between males and females in sealant loss (anatomical form) in the three groups at three, six and 12 months. A total of 128 teeth were sealed with sealant alone; out of which, 12 teeth had fluorosis and 116 teeth did not have fluorosis; while 64 teeth received sealant along with fifth generation bonding agent; out of which, six teeth had fluorosis and 58 did not. Of the remaining 64 teeth that received sealant along with seventh generation bonding agent, six teeth had fluorosis and 58 did not. Statistically, no significant difference was found in sealant loss (anatomical form) between the teeth with and without fluorosis in each group at three, six and 12 months (Table 1). Comparison of anatomical form among all the groups at three, six and 12 months revealed statistically significant differences between fifth and seventh generation and fifth generation and sealant groups while no significant difference was found between seventh generation and sealant group.

Statistically, no significant difference was found for marginal discoloration and marginal integrity among all the three groups at three, six and 12 months (Table 2). There was no statistically significant difference between baseline and three months, three and six months and six and 12 months among the fifth generation, seventh generation and sealant groups in this respect (Table 3).

DISCUSSION

Pit and fissure sealants have been accepted as an effective caries prevention method [16]. The sealant application is highly technique sensitive and salivary contamination is the most common factor decreasing the success rate of sealants; insufficient etching, entrapment of air bubbles in the sealant material and incomplete removal of debris from the pits and fissures before the etching process can also compromise sealant success [3]. Acid etching is the most critical step in sealant application. Salivary contimation prior to sealant placement will cause adherence of salivary proteins to the etched enamel leading to remineralization of enamel, which will interfere with sealant penetration and thereby reducing the bond strength of sealant [17].

To prevent salivary contamination of the etched enamel, hydrophilic resins were added to sealants, which are insensitive to salivary contamination and also decrease the viscosity of adhesive. A low-viscosity adhesive spread uniformly over a tooth surface increases the ability of sealant to adhere to micro-retentive grroves on tooth surfaces, having a surface energy less than that of free surface energy of the substrate [18,19].

Priming the etched enamel with a dentin-bonding agent prior to placement of a sealant can increase surface wettability and contact of sealant and the substrate by removing contaminants [20].

In the current study, evaluation criteria of Fegial et al. [15] was considered to record marginal Integrity, marginal discoloration and anatomical form. Marginal discolorstion occurs when there is marginal breakdown, creating a rough and irregular surface. This can act as a niche for the accumulation of plaque and food debris and also promote the penetration of oral fluids and cause microleakage, so as that of anatomical form (retention). Anatomical form indicates the morphology of tooth where the sealant was placed. In the current study, out of 64 children six had mild fluorosis; whereas the remaining 58 did not. When comparing sealant retention (anatomical form) between fluorotic and non-fluorotic teeth, no statistically significant difference was seen.

This result is in agreement with that of Isci et al, in 2010; they found no statistically significant difference in sealant retention between mild fluorotic and non-fluorotic teeth [21]. This might be due to no change in the prismatic structure of enamel in non-fluorotic and mild fluorotic teeth after etching.

Table 1. Comparison of sealant loss (anatomical form) between teeth with and without fluorosis at three months, six months and 12 months.

	Fluorotic Teeth (F) (%)	Non fluorotic Teeth (NF) (%)	3 months			6 months			12 months		
			F(%)	NF(%)	P	F(%)	NF(%)	P	F(%)	NF(%)	P
Sealant alone (N=128)	0/12	0/116	1/10(0.1)	2/112(0.01)	0.228	1/10(0.1)	3/108(0.02)	0.302	1/10(0.01)	3/112(0.02)	0.293
5th Generation (N=64)	0/6	0/58	2/5(0.4)	4/56(0.07)	0.071	2/5(0.4)	5/54(0.09)	0.102	2/5(0.4)	5/56(0.08)	0.096
7th Generation (N=64)	0/6	0/58	1/5(0.2)	1/56(0.01)	0.159	1/5(0.2)	1/54(0.01)	0.164	1/5(0.2)	1/56(0.01)	0.159

*Chi square test at P<0.05 level of significance

**Dropout of 3, 5 and 3 patients at 3, 6 and 12 months, respectively.

Table 2. Comparison of marginal discoloration, marginal integrity and anatomical form among the groups at three, six and 12 months.

	3 months				6 months				12 months			
	Total number of teeth	**Marginal discoloration**	**Marginal integrity**	**Anatomical form**	**Total number of teeth**	**Marginal discoloration**	**Marginal integrity**	**Anatomical form**	**Total number of teeth**	**Marginal discoloration**	**Marginal integrity**	**Anatomical form**
5th generation	61	1	3	6	59	2	3	7	61	2	4	7
7th generation	61	0	1	2	59	0	1	3	61	2	2	3
Sealant	122	0	1	3	118	1	1	3	122	1	1	4
5th vs 7th generations		P=0.315	P=0.309	P=0.042**(S)**		P=0.362	P=0.361	P=0.039**(S)**		P=1	P=1	P=0.041**(S)**
5th generationvs Sealant		P=0.156	P=0.074	P=0.049**(S)**		P=0.320	P=0.168	P=0.041**(S)**		P=0.217	P=0.217	P=0.035**(S)**
7th generationvs Sealant		P=1	P=0.615	P=0.606		P=0.478	P=0.286	P=0.222		P=0.217	P=0.217	P=0.741

S: significant

*Chi square test at P<0.05 level of significance

**Dropout of 3, 5 and 3 patients at 3, 6 and 12 months, respectively.

In the current study, the teeth with severe fluorosis were excluded, because to obtain the same etching pattern as that of normal enamel, the etching time should be increased for up to 120 to 180 seconds, as fluorapetite crystals are acid resistant, whereas in mild fluorosis the usual etching time would suffice (30 seconds).

The fifth generation bonding agent is the most commonly used bonding agent [15].

We tested the fifth generation bonding agent (Prime and Bond NT), which has a unique combination of PENTA chemistry and nanofiller particles.

PENTA forms a chemical bond to tooth calcium which provides a unique combination of micromechanical and chemical bonding along with a modulus of elasticity that improves marginal seal, minimizes postoperative sensitivity and protects against secondary caries.

The results of our study indicated that the application of fifth generation bonding agent prior to fissure sealant did not increase the retention rate at the end of one year, which was similar to the result of studies done by Ansari and Hashemi [20] and Boksman et al [22].

However, an evidence-based study by Locker et al, in 2003 concluded that application of a bonding agent prior to the sealant use does not appear to enhance retention rates [23].

Although not contraindicated, due to some clinical limitations such as being time consuming, cost effectiveness and doubtful retention, routine use of a fifth generation bonding agent as part of sealant application technique is not recommended. Unlike the fifth generation, we can cut short the cost and time by using seventh generation bonding agent for sealants as the etching and rinsing steps are skipped; it increases patient comfort, reduces chairside time, decreases contamination, and increases the efficacy of resin restoration [24]. Seventh generation bonding agents also known as self-etch adhesive bonding agents perform etching, disinfecting, desensitizing, priming and bonding all in a single step. We considered tert-Butanol and functionalized phosphoric acid ester as a basic constituent of bonding agent. Tert-Butanol is a solvent with a well-balanced polarity; it uses acrylic amide resin, which makes the formulation less susceptible to hydrolysis in aqueous form. This bonding agent uses inverse functionalized phosphoric acid esters that have a hydrolysis-stable ether bond. Exclusive bond durability of self-etch (Xeno V) adhesive lies in the fact that much of the calcium is available for the additional chemical interactions with specific adhesive monomers as all of the hydroxyapetites are not removed from the interaction zone.

Table 3. Comparison of sealant retention at different time intervals.

	Baseline	**Baseline - 3 months**			**3 months - 6 months**			**6 months - 12 months**		
	Total number of teeth	**Total number of teeth**	**Loss (%)**	**P-value**	**Total number of teeth**	**Loss (%)**	**P-value**	**Total number of teeth**	**Loss (%)**	**P-value**
5th Generation	64	61	6 (9.84)	0.145	59	1 (2.06)	0.721	61	0 (0)	0.947
7th Generation	64	61	2 (3.3)	0.319	59	1 (0.1)	0.973	61	0 (0)	0.973
Sealant	128	122	3 (2.5)	0.563	118	0 (0)	0.668	122	1 (0.7)	0.962

*Chi square test at P<0.05 level of significance

Therefore, bonds are stable, even in the aqueous environment and this mechanism is supposed to protract the clinical service of restorations [25]. Also, self-etch adhesives prevent the hydrolysis of collagen and thus decrease the early degradation of bonds.

The limited technique sensitivity combined with simple and time saving application method as well as eliminating the rinsing step render sealant placement along with a seventh generation bonding agent a true alternative especially in children. In the current study, the frequency of anatomical form (sealant retention) for seventh generation after three, six and 12 months was 96.7%, 94.8% and 95%, respectively. The results of our study were similar to those of Pinar et al, since they reported a retention rate of 98% after three and six months and 81% after 12 months [26].

However, conflicting results have been published concerning the need for a bonding agent; it was found that the use of a seventh generation bonding agent prior to application of fissure sealants did not increase the retention rate compared to sealant alone [24].

The greater loss of sealant retention (anatomical form) in the fifth generation can be attributed to technical sensitivity or technical errors. As multiple steps were required for the application of fifth generation bonding agent, risks of moisture contamination and consequently poor sealant retention would be higher, which can be reflected in the results as major loss of sealant occurred in the first follow up. Seventh generation group in our study was comparable to the teeth sealed with sealant alone, which is similar to the study done by Das et al [25].

Considering the simple procedure employed and less time consumed, there would be lower risk of technical errors mainly moisture contamination in the teeth sealed with a seventh generation bonding agent.

CONCLUSION

Complete control of salivary contamination is difficult to achieve, therefore application of a hydrophilic bonding agent, which is insensitive to moisture may increase the sealant retention. As etch and rinse steps are not required separately for a seventh generation bonding agent, application of sealant in large-scale caries prevention programs may be quite easy, affordable and successful. Further in-vivo long-term follow up studies should be conducted on a heterogeneous population to compare sealant success using different adhesive systems.

REFERENCES

1- Perdigao J, Swift EJ. Fundamental Concepts of Dental Adhesion. In: Roberson TM, Heymann HO, Swift EJ, editors. Sturdevant's Art and Science of Operative Dentistry. 5th ed., St Louis: Mosby, Elsevier; 2006:249.

2- Edelstein BL.The Dental Caries Pandemic and Disparities Problem. BMC Oral Health. 2006 Jun 15;6 Suppl 1:S2.

3- Waggoner WF, Siegal M. Pit and fissure sealant application: updating the technique. J Am Dent Assoc. 1996 Mar;127(3):351-61.

4- Weintraub JA. Pit and fissure sealants in high caries- risk individuals. J Dent Educ. 2001 Oct;65(10):1084-90.

5- Muller-Bolla M, Lupi-Pégurier L, Tardieu C, Velly AM, Antomarchi C. Retention of resin-based pit and fissure sealants: A systematic review. Community Dent Oral Epidemiol. 2006 Oct;34(5):321-36.

6- Cueto El, Buonocore MG. Sealing of pits and fissures with an adhesive resin: its use in caries prevention. J Am Dent Assoc. 1967 Jul;75(1):121-8.

7- Council on Dental Materials and Devices. Pit and fissure sealants. J Am Dent Assoc. 1971 May;82(5):1101-3.

8- Swift EJ Jr. Dentin/enamel adhesives: review of the literature: Pediatr Dent. 2002 Sep-Oct;24(5):456-61.

9- Simonsen RJ. The clinical effectiveness of a colored pit and fissure sealant at 36 months.

J Am Dent Assoc. 1981 Mar;102(3):323-7.
10- Hitt JC, Feigal RJ. Use of a bonding agent to reduce sealant sensitivity to moisture contamination: an in vitro study. Pediatr Dent. 1992 Jan-Feb;14(1):41-6.
11- Fritz UB, Finger WJ, Stean H. Salivary contamination during bonding procedures with one-bottle adhesive system. Quintessence Int. 1998 Sep;29(9):567-72.
12- Borem LM, Feigal RJ. Reducing microleakage of sealants under salivary contamination: digital-image analysis evaluation. Quintessence Int. 1994 Apr;25(4): 283-9.
13- Symons AL, Chu CY, Meyers IA. The effect of fissure morphology and pretreatment of the enamel surface on penetration and adhesion of fissure sealants. J Oral Rehabil. 1996 Dec;23(12):791-8.
14- Peumans M, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B. Clinical effectiveness of contemporary adhesives: a systematic review of current clinical trials. Dent Mater. 2005 Sep;21 (9):864-81.
15- Feigal RJ, Musherure P, Gillespie B, Levy-Polack M, Quelhas I, Hebling J. Improved sealant retention with bonding agents: a clinical study of two-bottle and single-bottle systems. J Dent Res 2000 Nov 1;79 (11):1850-6.
16- KERVANTO-SEPPÄLÄ SA, Lavonius E, PIETILÄ I, PITKÄNIEMI J, Meurman JH, Kerosuo E. Comparing the caries-preventive effect of two fissure sealing modalities in public health care: a single application of glass ionomer and a routine resin-based sealant programme. A randomized split-mouth clinical trial. Int J Paed Dent 2008 Jan 1;18 (1):56-61.
17- Hormati AA, Fuller JL, Denehy GE. Effects of contamination and mechanical disturbance on the quality of acid-etched enamel. J Am Dent Assoc. 1980 Jan;100(1): 34-8.
18- Erickson RL. Surface interactions of dental adhesive materials. Oper Dent. 1992;Suppl 5:81-94.
19- Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P, et al. Adhesion to enamel and dentin: Current status and future challenges. Oper Dent. 2003 May-Jun;28(3): 215-35.
20- Ansari ZJ, Hashemi SM. Effect of enamel bonding agents on pit and fissure sealant retention in an isolated situation. J Dent (Tehran). 2008;5(4):156-60.
21- Isci D, Sahin Saglam AM, Alkis H, Elekdag-Turk S, Turk T. Effects of fluorosis on the shear bond strength of orthodontic brackets bonded with a self-etching primer. Eur J Orthod. 2011 Apr;33(2):161-6.
22- Boksman L, McConnell RJ, Carson B, McCutcheon-Jones EF. A 2-year clinical evaluation of two pit and fissure sealants placed with and without the use of a bonding agent. Quintessence Int. 1993 Feb;24(2):131-3.
23- Locker D, Jokovic A, Kay EJ. Prevention. Part 8: The use of pit and fissure sealants in preventing caries in the permanent dentition of children. Br Dent J. 2003 Oct 11;195(7):375-8.
24- Das UM, Viswanath D, Venkatasubramanian R, Gopal S. Retention of pit and fissure sealants with and without seventh generation bonding agents: A clinical study. Dent India. 2008;2(1).
25- Kiremitci A, Yalcin F, Gokalp S. Effectiveness of three dentin adhesive systems on adhesion of resin composite to both dentin and ground enamel. Quintessence Int. 2004 May;35(5):367-70.
26- Pinar A, Sepet E, Aren G, Bölükbaşi N, Ulukapi H, Turan N. Clinical performance of sealants with and without a bonding agent. Quintessence Int. 2005 May;36(5):355-60.