Print ISSN: 2321-6379
Online ISSN: 2321-595X

Original Article

Evaluation of Two Adhesive Systems on the Pit and Fissure Sealant Success in Permanent Molars: An *In vivo* Study

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Abstract

Introduction: Fissure sealants were first introduced in 1967 by Cueto and Buonocore and their effectiveness was recognized by the American Dental Association in 1971. The fifth-generation adhesive system sealants were traditionally placed (which is a two-bottle system). The seventh-generation bonding agents, introduced in the early 2000s, contain acidic primers and adhesive monomers in a single bottle.

Materials and Methods: All the schools with the children aged 6–13 years situated in Bareilly city were enlisted. From the list of schools, four schools were randomly selected by simple random sampling method. Clinical evaluation of marginal integrity, discoloration, and anatomical form will be rated at baseline, 1st month, 3rd month, and after 6 months.

Results: Out of 60 schoolchildren, there were 33 males and 27 females. The 5th generation had more loss in anatomical form as compared the 7th generation bonding agent group and sealant alone group and was statistically significant.

Discussion: The 7th generation bond has more retention because, relative to the 5th generation bonding agent, it has greater microtensile bond strength. Compared to the 7th generation group, more losses were seen in the 5th generation group at first follow-up. This may be attributed to the technique sensitivity at the time of sealant application. Since several steps were needed for the application of the bonding agent of the 5th generation, there are more chances of contamination of moisture that causes sealant retention failure.

Conclusions: Since etch-and-rinse steps for the seventh-generation bonding agent are not needed separately, it can be recommended that the application of sealant along with the seventh-generation bonding agent can improve the success of the sealant and can also be used in field preventive programs for caries prevention.

Key words: Bonding agents, Pit and fissures, Sealant

INTRODUCTION

Among the various chronic diseases, dental caries is among the most common one. Dental caries is a multifactorial microbial infectious disease characterized by demineralization of the inorganic and destruction of the organic substance of the tooth. These microorganisms are mainly found in the pit and fissures of the tooth. The World Health Organization reported the prevalence of caries in school-aged children to be 60–90%.[1]

Of all caries in children, 75% were found in pits and fissures.[2,3] However, the use of pit and fissure sealant forms an integral part of primary prevention, especially in children, because they offer specific protection against the occurrence and progression of dental caries. They have also been proven very cost effective as compared to other restorative materials. Fissure sealants were first introduced in 1967 by Cueto and Buonocore[4] and their effectiveness was recognized by the American Dental Association in 1971.[5]

Access this article online

www.ijss-sn.com

Month of Submission : 02-2021
Month of Peer Review : 03-2021
Month of Acceptance : 03-2021
Month of Publishing : 04-2021

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The rationale behind fissure sealants is that it provides a physical barrier between the microorganisms and the healthy tooth structure underneath. The chances of caries development beneath it will be minimal as long as the sealant remains intact. However, due to inadvertent moisture and salivary contamination of etched surface, the application of sealants is not as high as expected.

It is generally observed that an adhesive must initially wet the substrate to form a strong bond with that substrate. Therefore, maximizing the wettability of the tooth surface is critical in achieving a successful bond.[6] Recent work on improved bonding of sealants to saliva-contaminated enamel may help improve clinician confidence in sealant success, even in circumstances of application that is less than ideal.[7]

The fifth-generation adhesive system sealants were traditionally placed (which is a two-bottle system). As it is a multistep technique, it would increase chair side time, patient discomfort, and risk of salivary contamination. To overcome this problem, the seventh-generation bonding agents (which are a one-bottle technique) were introduced. The 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.[8]

As only a few studies have compared clinical sealant success after the application of different bonding agents, thus the aim of this study was to compare the effect of the fifth- and seventh-generation bonding agents on pit and fissure sealant success.

MATERIALS AND METHODS

The study was done among 6–13-year-old schoolchildren. This study has been reviewed and approved by the Ethical Committee of the Institute of Dental Sciences Bareilly. Permission was obtained from the respective school authorities to conduct the survey in the selected schools. Informed consent was also obtained from the parents and their children for the study.

The objectives were to evaluate the marginal integrity, marginal discoloration, and anatomical form of pit and fissure sealant restoration on the occlusal surface.

Figure 1: Screening of schoolchildren

Figure 2: Armamentarium used in the study

Figure 3: Application of etchant on tooth surface

Table 1: Comparison of sealant loss (anatomical form) among males and females at 1, 3 and 6 month interval

Sealant with 5th and 7th gen.bonding agents	Baseline		1 month			3 months			6 months		
	Males teeth	Females teeth	M	F	*P*-value	M	F	*P*-value	M	F	*P*-value
Sealant alone (120)	0/66	0/54	1/62	2/54	1.000	3/64	1/54	1.000	1/62	3/54	1.000
Sealant+5th generation bonding agent (60)	0/33	0/27	3/31	2/27	1.000	4/32	4/27	1.000	5/31	2/27	1.000
Sealant+7th generation bonding agent (60)	0/33	0/27	1/31	2/27	1.000	0/32	1/27	1.000	1/31	1/27	1.000

M: Male, F: Female

Inclusion Criteria

The following criteria were included in the study:

- Children belonging to the age group of 6–13 years
- Children whose parents or guardians gave voluntary informed written consent
- Fully erupted bilateral permanent 1st or 2nd molar teeth in both upper and lower arches
- Deep occlusal pits and fissures in molar teeth.

Exclusion Criteria

The following criteria were excluded from the study:

- Subjects with one carious or restored permanent 1st or 2nd molar tooth on either side
- Molar teeth with the missing antagonistic teeth
- Subjects having some form of physical or mental disorder
- Uncooperative patients
- Children who would migrate within 1 year.

The kappa coefficient value for the reliability of intraexaminer, for the detection of marginal integrity, marginal discoloration, and anatomical form was found to be 0.82, 0.84, and 0.90, respectively. These values reflect a high degree of observational conformity.

All the schools with the children aged 6–13 years situated in Bareilly city were enlisted. From the list of schools, four schools were randomly selected by simple random sampling method [Figure 1]. Screening of all the children aged 6–13 years was done. Of the screened students who met the inclusion and exclusion criteria and gave consent, 60 subjects (33 males; 27 females) were selected. The informed consent forms were distributed among the

Table 2: Distribution of sealed teeth with and without bonding agent

Sealant with 5th and 7th gen. bonding agents	Total no. of teeth	Maxillary teeth	Mandibular teeth
Sealant alone	120	60	60
Sealant+5th Gen. bonding agent	60	30	30
Sealant+7th Gen. bonding agent	60	30	30

*Fisher's exact test used at $P < 0.05$ significant, **An attrition of 2, 1, and 2 subjects at 1, 3, and 6 months, respectively

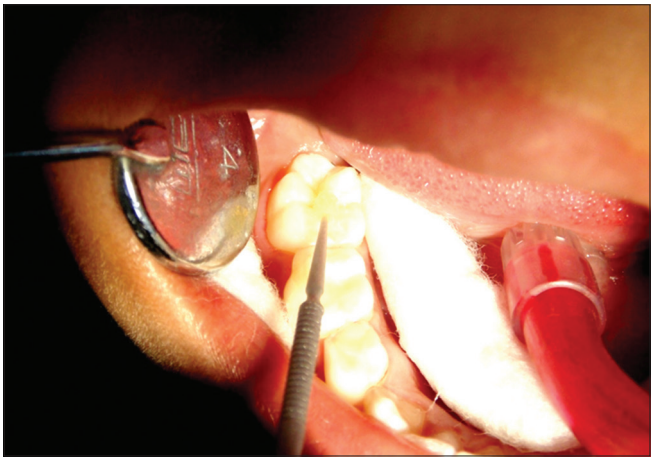

Figure 4: Application of bonding agent on tooth surface

Figure 5: Application of sealant on tooth surface

Table 3: Comparison of sealant retention (anatomical form) among maxillary and mandibular teeth at 1, 3, and 6 months interval

Sealant distribution among maxillary and mandibular teeth	Baseline	1 month			3 months				6 months			
	Total no. of teeth	Total no. of teeth	No loss	Partial loss	Complete loss	Total no. of teeth	No loss	Partial loss	Complete loss	Total no. of teeth	No loss	Partial loss	Complete loss
5th generation													
Maxilla	30	29	27	1	1	30	27	1	2	29	26	1	2
Mandible	30	29	26	2	1	29	27	0	2	29	26	0	3
		χ^2=2.93; P=0.315				χ^2=1.99; P=0.812				χ^2=2.13; P=0.504			
7th generation													
Maxilla	30	29	28	1	0	29	28	1	0	29	29	0	1
Mandible	30	29	29	0	0	30	29	1	0	29	28	1	0
		χ^2=0.001; P=0.821				χ^2=0.001; P=0.981				χ^2=0.001; P=0.821			
Sealant													
Maxilla	60	58	57	1	0	59	57	1	1	58	57	1	1
Mandible	60	58	57	1	0	59	58	1	0	58	58	1	0
		χ^2=0.99; P=0.589				χ^2=1.01; P=0.431				χ^2=0.001; P=0.821			

*Chi-square test at $P < 0.05$ significant, **An attrition of 2, 1, and 2 subjects at 1, 3, and 6 months, respectively

Table 4: Comparison of Marginal Discoloration, Marginal Integrity and Anatomical Form in 5th generation group at 1, 3 and 6 month interval

	5th generation						
Marginal Discoloration, Marginal Integrity, Anatomical Form at 1, 3 and 6 months with 5th generation bonding agent	Baseline no. of tooth (%)	1 month		3 months		6 months	
		No. of tooth (%)	Significance of difference as compared to baseline (Fisher's exact test)	No. of tooth (%)	Significance of difference as compared to baseline (Fisher exact test)	No. of tooth (%)	Significance of difference as compared to baseline (Fisher 's exact test)
Marginal discoloration	0/60 (0)	2/58 (3.44)	0.348 (NS)	3/59 (5.08)	0.392 (NS)	3/58 (5.17)	0.236 (NS)
Marginal integrity	0/60 (0)	2/58 (3.44)	0.413 (NS)	3/59 (5.08)	0.392 (NS)	4/58 (6.89)	0.061 (NS)
Anatomical form	0/60 (0)	5/58 (8.62)	0.023 (S)	5/59 (8.47)	0.011 (S)	6/58 (10.34)	0.012 (S)

*Fisher's exact test at $P < 0.05$ significant, **An attrition of 2, 1, and 2 at subjects 1, 3, and 6 months, respectively

Table 5: Comparison of marginal discoloration, marginal integrity, and anatomical form in the 7th generation group at 1, 3, and 6 months interval

	7th generation						
Marginal Discoloration, Marginal Integrity, Anatomical Form at 1, 3 and 6 months with 7th generation bonding agent	Baseline no. of tooth	1 month		3 months		6 months	
		No. of tooth	Significance of difference as compared to baseline (Fisher exact test)	No. of tooth	Significance of difference as compared to baseline (Fisher exact test)	No. of tooth	Significance of difference as compared to baseline (Fisher's exact test)
Marginal discoloration	0/60 (0)	0/58 (0)	0.89 (NS)	1/59 (1.69)	0.137 (NS)	1/58 (1.72)	0.236 (NS)
Marginal integrity	0/60 (0)	1/58 (1.72)	0.23 (NS)	2/59 (3.39)	0.517 (NS)	3/58 (5.17)	0.127 (NS)
Anatomical form	0/60 (0)	1/58 (1.72)	0.23 (NS)	2/59 (3.39)	0.517 (NS)	2/58 (3.44)	0.127 (NS)

*Fisher's exact test at $P < 0.05$ significant. **An attrition of 2, 1, and 2 subjects at 1, 3, and 6 months, respectively

Table 6: Comparison of marginal discoloration, marginal integrity, and anatomical form in sealant group at 1, 3, and 6 months interval

	Sealant						
Marginal Discoloration, Marginal Integrity, Anatomical Form at 1, 3 and 6 months with sealant	Baseline no. of tooth	1 month		3 months		6 months	
		No. of tooth	Significance of difference as compared to baseline (Fisher's exact test)	No. of tooth	Significance of difference as compared to baseline (Fisher's exact test)	No. of tooth	Significance of difference as compared to baseline (Fisher's exact test)
Marginal discoloration	0/120 (0)	1/116 (0.86)	0.321 (NS)	1/118 (0.84)	0.210 (NS)	1/116 (0.86)	0.321 (NS)
Marginal integrity	0/120 (0)	0/116 (0)	0.511 (NS)	1/118 (0.84)	0.210 (NS)	3/116 (2.5)	0.321 (NS)
Anatomical form	0/120 (0)	2/116 (1.72)	0.511 (NS)	3/118 (2.54)	0.612 (NS)	3/116 (2.5)	0.321 (NS)

*Fisher's exact test at $P < 0.05$ significant

participants on school working days and were instructed to get it signed by their parents before returning the same to the examiner on the next day. Sealant was placed in such a manner that out of 240 teeth, sealant along with the fifth-generation bonding agent was placed on 60 teeth, that is, 15 maxillary right molar, 15 maxillary left molar, 15 mandibular right molar, and 15 mandibular left molar. Similarly, 60 teeth were sealed with sealant along with the seventh-generation bonding agent and remaining 120 contralateral teeth were sealed with sealant alone (split mouth design). Explorer was used to check the sealant retention. Micromotor headpiece and finishing burs were used to make the necessary occlusal adjustments. For the maintenance of the oral hygiene, instructions were given to all the study subjects [Figure 2].

Clinical evaluation of marginal integrity, discoloration, and anatomical form will be rated at baseline, 1st month, 3rd month, and after 6 months [Figures 3-5]. After drying each tooth, the detailed examination was done to assess the sealant success, according to the criteria given by Feigal *et al.*

A total of 58 subjects were available at first follow-up visit (after 1 month), that is, two subjects were not present on the follow-up day. A total of 59 subjects were available at second visit (after 3 months), and finally, 58 subjects were present at the final follow-up (6 months).

Statistical Analysis

The statistical analysis was done using Statistical Package for the Social Sciences Version 22.0 statistical analysis software.

The values were represented in number and percentages (%). Fisher's exact *t*-test and Chi-square tests were used.

RESULTS

Table 1 shows the distribution of teeth for sealant placement in maxillary and mandibular arches. Out of 240 teeth, 120 teeth (60 teeth in maxilla and 60 teeth in mandible) were sealed with sealant alone, 60 teeth (30 teeth in maxilla and 30 teeth in mandible) were sealed with sealant plus fifth-generation bonding agent and 60 teeth (30 teeth in maxilla and 30 teeth in mandible) were sealed with sealant plus seventh-generation bonding agent.

In Table 2, out of 60 schoolchildren, there were 33 males and 27 females. Sixty-six teeth in males and 54 teeth in females were receiving sealant alone while 33 teeth in males and 27 teeth in females each were receiving sealant along with the 5th generation and 7th generation bonding agents. There was no statistically significant difference found in sealant loss (anatomical form) among all the three groups at 1, 3, and 6 months interval.

Table 3 shows that 30 teeth in maxilla and 30 teeth in mandible received sealant along with 5th generation and 7th generation bonding agent whereas 60 teeth in maxilla and 60 teeth in mandible received sealant alone. There was no statistically significant difference found in sealant retention among maxillary and mandibular teeth in 5th generation, 7th generation and sealant alone at 1, 3 and 6 months of interval.

The comparison of marginal discoloration, marginal integrity and anatomical form in 5th generation group at 1, 3 and 6 month intervalis shown in Tables 4 and 5 shows the comparison of Marginal discoloration, Marginal integrity and Anatomical form in 7th generation group at 1, 3 and 6 month interval. Similarly Table 6 shows the comparison of Marginal Discoloration, Marginal Integrity and Anatomical Form in sealant group at 1, 3 and 6 month interval. Table 7 shows the comparison of marginal discoloration, marginal integrity and anatomical form among all the groups at 1, 3 and 6 month of interval. There was no statistically significant difference found among all the three groups. Table 8 shows the comparison of sealant retention (anatomical form) between baseline and 1month, 1 and 3 months and 3 and 6 months among 5th generation, 7th generation and sealant group. There was no statistically significant difference found among all the three groups.

Table 7: Comparison of marginal discoloration, marginal integrity, and anatomical form among all the groups at 1, 3, and 6 months interval

Intergroup comparison	1 month						3 months						6 months					
	Total no. of teeth	Marginal discoloration scores			Marginal integrity scores		Anatomical form scores		Total no. of teeth	Marginal Discoloration Scores			Marginal integrity scores			Anatomical form scores			Total no. of teeth	Marginal discoloration scores			Marginal integrity scores			Anatomical form scores		
		0	1	3	0	1	3	0	2b	3		0	1	3	0	1	3	0	2b	3		0	1	3	0	1	3	0	2b	3
5th generation	58	56	2	-	54	2	-	53	3	2	59	56	2	1	56	2	1	54	3	2	58	55	2	1	56	2	2	52	3	3
7th generation	58	58	-	-	57	1	-	57	1	-	59	59	-	1	59	1	1	57	1	1	58	57	-	1	58	2	1	57	1	1
Sealant	116	115	-	1	114	-	-	114	1	1	118	117	-	1	117	-	1	115	2	1	116	115	-	1	115	2	1	115	2	1
Overall (among groups)		χ^2=2.103;			χ^2=2.45;			χ^2=2.082;				χ^2=3.03;			χ^2=2.06;			χ^2=7.85;				χ^2=2.713;			χ^2=1.916;			χ^2=4.38;		
		P=0.326			*P*=0.159			*P*=0.102				*P*=0.301			*P*=0.436			*P*=0.051				*P*=0.273			*P*=0.384			*P*=0.130		
5th versus 7th Gen		χ^2=1.318;			χ^2=0.017;			χ^2=1.77;				χ^2=1.15;			χ^2=1.03;			χ^2=4.12;				χ^2=0.321;			χ^2=0.134;			χ^2=0.86;		
		P=0.215			*P*=0.279			*P*=0.121				*P*=0.251			*P*=0.251			*P*=0.062				*P*=1.001			*P*=1.011			*P*=0.285		
5th Gen versus sealant		χ^2=1.921;			χ^2=2.052;			χ^2=3.62;				χ^2=1.14;			χ^2=2.46;			χ^2=3.83;				χ^2=0.414;			χ^2=0.414;			χ^2=4.03;		
		P=0.197			*P*=0.062			*P*=0.082				*P*=0.210			*P*=0.168			*P*=0.074				*P*=0.106			*P*=0.106			*P*=0.060		
7th Gen versus sealant		χ^2=0; *P*=1			χ^2=0.121;			χ^2=0.99;				χ^2=0.467;			χ^2=1.40;			χ^2=2.02;				χ^2=0.414;			χ^2=0.414;			χ^2=0.500;		
					P=0.302			*P*=0.303				*P*=0.367			*P*=0.145			*P*=0.111				*P*=0.106			*P*=0.106			*P*=0.621		

*Chi-square test at $P < 0.05$ significant, **An attrition of 2, 1, and 2 subjects at 1, 3, and 6 months, respectively

DISCUSSION

5th Generation Versus Sealant

Out of 60 schoolchildren, 33 in males and 27 in females were receiving sealant along with the 5th generation bonding

agent. Statistically no significant difference was seen in sealant retention among males and females, which was similar to the study conducted by Kaur and Kaur,[9] whereas contradictory results were obtained in a study done by Jafarzadeh *et al.* in 2008 which stated that females had more sealant retention as compared to males, as in females, molars erupted early in the oral cavity as compared to males.[10]

In the present research, sealant retention loss was statistically non-significant as compared with maxillary and mandibular teeth at 1, 3, and 6 months periods, which is identical to the outcome of the study conducted by Bhushan and Goswami[11] and Tandon *et al.*[12] However, these findings were antithesis to the studies conducted by Kaur and Kaur,[9] AL-Sultani *et al.*,[13] and Rakesh *et al.*[14] which reported that upper teeth retained sealants better than the lower teeth. Such findings could be due to comparatively wider occlusal surface areas of mandibular teeth (as compared to maxillary teeth), which may allow the sealants to get more exposed to the oral atmosphere and reduce their retention.[14]

Anatomical Form

The percentage loss in anatomical forms at the end of 1, 3, and 6 months interval was 8.62%, 8.47%, and 10.34%, respectively, and statistically significant results were found ($P = 0.023$; $P = 0.011$; and $P = 0.012$). This finding was in contrary to the results obtained by Rakesh *et al.*[14] at 3 and 6 months interval. The authors in their study have concluded that pit and fissure sealants are successful in the prevention of dental caries, but no statistically significant variation was observed between retention of pit and fissure sealants.

7th Generation Versus Sealant

Sealant loss was recorded at 1, 3, and 6 months intervals for maxillary teeth and mandibular teeth, and this difference was found to be statistically non-significant, similar to the research conducted by Nikhil *et al.*[15] However, relative to mandibular teeth, the retention rate of maxillary molars was found to be poor and the difference was found by Feigal *et al.* to be statistically significant ($P = 0.03$). It agrees with previous evidence from going and associates (1977) and Horowitz *et al.* (1977), although there is no uniform finding in the literature on variance in sealant success by arch. However, equivalent declines between maxillary and mandibular molars were seen by an Australian clinical survey (Messer *et al.*, 1997), and others indicate slightly greater defects in mandibular sealants (Futatsuki *et al.*, 1995).[16]

Anatomical Form

At the end of the 1, 3, and 6 months interval, the percentage of marginal discoloration rates for teeth receiving sealant along with the 7th generation bonding agent was 1.72%, 3.39%, and 3.44%, respectively, and no statistically significant difference was found. Mohammad *et al.* also achieved similar findings in their research. The authors added that there were no statistically significant differences found in the retention of sealants by conventional acid etching and self-etching bonding agents. These results are similar to those of Boksman *et al.* who used ScotchBond 2 and universal bond and demonstrated no variations in sealant retention rates. Peng *et al.* in their analysis of the Adper Prompt SE adhesive and PAE system also did not find variations between the two groups at 12 months. These findings contrast with studies by Feigal *et al.* which documented improved preservation of sealants in teeth sealed with a primer and bond.[17]

On considering time period among the 7th generation group, the loss of sealant retention (anatomical form) between baseline and 1 month, 1 month and 3 months, and 3 months and 6 months interval was statistically non-significant.

5th versus 7th Generation Bonding Agent

When comparing the 5th generation to the 7th generation groups, the split mouth design was not considered as contralateral teeth were sealed with sealant alone.

Anatomical Form

Because more sealant retention losses (anatomical form) occurred in the 5th generation group relative to the 7th generation group, this difference was statistically significant. This result disagreed with a study performed by Aman *et al.*

Table 8: Comparison of sealant retention at different time interval

Overall comparison	Baseline	Baseline–1 month			1 month–3 months			3 months–6 months		
	Total no. of teeth	Total no. of teeth	Loss (%)		Total no. of teeth	Loss (%)		Total no. of teeth	Loss (%)	Chi-square; *P* value
5th generation	60	58	8.62	$\chi^2 = 0.345$; $P = 0.134$	59	1.9	$\chi^2 = 0.117$; $P = 0.611$	58	0.2	$\chi^2 = 0.003$; $P = 0.836$
7th generation	60	58	1.7	$\chi^2 = 0.213$; $P = 0.218$	59	1.6	$\chi^2 = 0.001$; $P = 0.672$	58	0.14	$\chi^2 = 0.001$; $P = 0.662$
Sealant	120	116	1.7	$\chi^2 = 0.115$; $P = 0.452$	118	0.8	$\chi^2 = 0.173$; $P = 0.338$	116	0.1	$\chi^2 = 0.003$; $P = 0.451$

*Chi-square test at $P < 0.05$ significant

in which, relative to the 7th generation bonding agent, a larger proportion of full retention was found in the total etch (5th generation bonding agent) arm.[18]

The 7th generation bond has more retention because, relative to the 5th generation bonding agent, it has greater microtensile bond strength.[19] Compared to the 7th generation group, more losses were seen in the 5th generation group at first follow-up. This may be attributed to the technique sensitivity at the time of sealant application. Since several steps were needed for the application of the bonding agent of the 5th generation, there are more chances of contamination of moisture that causes sealant retention failure.[20]

Literature does not include a clear response as to whether enamel bonded self-etch adhesives can survive the chemical and mechanical challenges of the oral cavity. Some clinical and experimental trials have found that the combination of self-etching adhesive systems with pit-and-fissure sealants is less effective than the use of etch-and-rinse adhesive systems.[19] Good results for this association have been reported by many other studies.[21,22]

Limitations

- Blinding could not be performed, as the operator and the examiner were the same person. To which extent, this factor affected the results of the study could not be assessed
- As the study was only for 6 months, long-term evaluation of the sealants could not be done.

CONCLUSIONS

Because it is difficult to obtain full monitoring of intraoral moisture, the development of a moisture-insensitive hydrophilic bonding agent will improve effective sealant retention. Since etch-and-rinse steps for the seventh-generation bonding agent are not needed separately, it can be recommended that the application of sealant along with the seventh-generation bonding agent can improve the success of the sealant and can also be used in field preventive programs for caries prevention.

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How to cite this article: Mir H, Shivalingesh KK, Srivastava D, Saleem A, Ashraf W, Pathak S. Evaluation of Two Adhesive Systems on the Pit and Fissure Sealant Success in Permanent Molars: An *In vivo* Study. Int J Sci Stud 2021;9(1):50-56.

Source of Support: Nil, **Conflicts of Interest:** None declared.