A One-Year Clinical Study of the Efficacy of a Pit-and-Fissure Sealant Containing Bioactive Glass

Edith Kouzmina[1], Tamara Smirnova[2], Nadezhda Pazdnikova[3]

[1] M.D., Ph.D., D.D.S. Professor, Head of Department of Preventive Dentistry, Moscow State University of Medicine & Dentistry, Moscow, Russia. [2] Ph.D. Head, Research Group on Preventive Dentistry, Moscow State University of Medicine & Dentistry, Moscow, Russia. [3] Teacher, Department of Preventive Dentistry, Moscow State University of Medicine & Dentistry, Moscow, Russia.

Abstract

Pit-and-fissure sealing is the most cost-effective method of occlusal caries prevention. Over the past ten years, a number of dental materials containing sealants with bioactive glass have been produced. They release fluoride and calcium, increasing the preventive effect. *Aim:* The aim of this study was to evaluate the retention rate and efficacy of a sealant with bioactive glass releasing fluoride and calcium. *Methods:* Esterfill Ca/F (Medpolimer, St Petersburg, Russia) was applied to the occlusal surfaces of permanent first molars (63 teeth) of 7-8-year-olds and second molars (65 teeth) of 12-13-year-olds. For most of the children, the sealant was applied to the occlusal surface of one maxillary/mandibular first molar or both, so that their contralateral sound molars remained unsealed as a control. At the same time, some children in the study received sealant on all four permanent first molars. *Results:* It was demonstrated that the fissure sealant with bioactive glass had quite good retention. After one year, 85.71% permanent first molars and 89.23% permanent second molars remained fully sealed and partial sealant retention was observed in 11.11% and 9.23% of these teeth. The sealant was 100% effective in the prevention of pit and fissure caries. No caries developed in occlusal surfaces where the sealant had been completely or partially lost. *Conclusions:* It can be concluded that:
- After one year, the fissure sealant containing bioactive glass had good retention rates with less than 3% total sealant loss.
- The sealant was effective in prevention of pit-and-fissure caries.
- There was no sign of caries development on occlusal surfaces where the sealant had been completely or partially lost.

Key Words: Occlusal Caries, Sealant, Fluoride, Bioactive Glass, Prevention

Introduction

Dental caries is the most common dental disease. Occlusal surfaces are considered to be highly susceptible to caries development because of their morphological complexity and plaque accumulation. Difficulties with brushing during tooth eruption and hypomineralisation of pits and fissures in children lead to early initiation and intensive progression of occlusal caries [1,2,3,4].

Pit-and-fissure sealing is the most effective method of occlusal caries prevention [5,6,7]. It is based on tight isolation of fissures from the external cariogenic environment.

In some developed countries, the sealing of pits and fissures has been part of national programmes for caries prevention since the 1960 and 1970s.

The first plastic materials used as occlusal sealants were polyurethanes and cyanoacrylates. However, they proved to be too soft and disintegrated after a short period of time [8,9].

Bowen (1963) designed a plastic resin, bisphenol-A-glycidyldimethacrylate (bis-GMA), that became the main component of modern sealants [10]. The acid-etch technique developed by Buonacore (1955) increased the adhesion of these materials to enamel surfaces [11]. Most second and third generation sealants that are currently used are filled composite resins, representing a mixture of organic resins with inorganic fillers.

It is important that sealants should create a mechanical barrier as well as promote mineralisation of underlying enamel. Minerals (such as fluoride and calcium) incorporated into a material can enhance its preventive effect.

The first fluoride-releasing materials used for

Corresponding author: Professor Edith Kouzima, Department of Preventive Dentistry, Moscow State University of Medicine and Dentistry, Moscow, Russia; e-mail: nocaries@mail.ru

sealing pits and fissures were glass-ionomer cements (GICs) and composite resins (Delton and its analogues), in which the polymer matrix contained inorganic (sodium, calcium or ytterbium fluoride) or organic fluoride [12].

Fluoride-containing sealants were seen to release much less fluoride than GICs and their retention rate is comparable to that of conventional sealants [13,14]. However, their greater caries prevention efficacy has not yet been proven in long-term clinical studies [15].

Currently, fluoride is incorporated into sealants through the filler in the form of strontium-fluoride-aluminosilicate glass. Fluoride release from these materials occurs due to the complex mechanisms of hydrolysis, external and internal diffusion. It depends on fluoride's ability to leach out from the material and to be substituted with other free ions from saliva.

Over the past ten years, some dental materials with bioactive glass, which releases either fluoride or calcium, have been produced. Composite resins with bioactive glass are Deguseal mineral (Evonik Degussa, Moscow, Russia), Ariston pHc and Ariston Liner (Ivoclar Vivadent, Moscow, Russia), as well as light-cured sealants Esterfill Ca and Esterfill Ca/F (Medpolimer, St Petersburg, Russia).

Aim

The aim of this study was to evaluate the retention rate and clinical efficacy of a sealant containing bioactive glass.

Methods

Fifty-six children from a Moscow comprehensive school having at least one permanent first (7-8-year-olds) or second (12-13-year-olds) molar fully erupted and caries free were randomly selected to participate in the trial.

Clinical examination of children included evaluation of their caries experience (DMFT and dmft score) and oral hygiene level Patient Hygiene Performance (PHP) Index. Sealant Esterfill Ca/F releasing fluoride and calcium was applied to the occlusal surfaces of their sound molars. Before the trial, children and their parents had been informed about the procedure of pit-and-fissure sealing. The parents signed informed treatment consent if they agreed to the child's participation in the trial. The study was approved by the relevant ethical committee.

The children were trained and motivated to perform adequate oral hygiene measures (tooth-brushing, flossing) during the study.

The children were divided into two groups in accordance with their age and teeth to be sealed. The first group consisted of 26 children aged 7-8 years. The sealant was applied to the occlusal surfaces of their permanent first molars (63 teeth). The second group was formed from thirty 12-13-year-olds, whose second molars were sealed (65 teeth). For most children, a split-mouth experimental design was used and sealant applied to the occlusal surface of one maxillary or mandibular molar or both, so that the contralateral sound molars remained unsealed as controls. Several children had four teeth sealed. The number of sealed maxillary and mandibular molars in both groups was approximately equal.

The sealant application in sound fissures was performed using a non-invasive technique in which occlusal surfaces were cleaned using a rotary brush and non-fluoridated polishing paste, thoroughly rinsed with a water spray, and dried with the air syringe. Cotton rolls were used for isolation. The teeth were then etched with 37% orthophosphoric acid for 30 seconds, washed for 20 seconds, isolated, and finally dried. The sealant was applied and photopolymerised according to the manufacturer's instructions. After removing isolation materials, the patient's occlusion was checked.

A total of 128 teeth treated with a single Esterfill Ca/F application were examined after 3, 6 and 12 months. Fresh sealant was not added if some sealant had been lost between examinations. Clinical effectiveness of Esterfill Ca/F was evaluated for the sealant's retention rate and anticariogenic action.

For direct clinical evaluation of restorations, the Ryge-criteria [16]—recommended by the American Dental Association (ADA)—were used and adapted to the sealant assessment *(Table 1)*.

The following clinical parameters were used: marginal adaptation, sealant retention, fissure caries development, roughness of sealant surface, and change of colour around the sealant.

Results

Initial examination showed that at baseline, in 7-8-year-olds the average DMFT and dmft scores were 0.2±0.08 and 4.1±0.6 respectively. In the group of 12-13-year-olds, the average DMFT score was 2.9±0.3.

Table 1. Criteria for clinical evaluation of sealant

Rating		Description
1. Marginal adaptation		
A	Alfa	No visible evidence of a crevice along the margin of the sealant that the explorer could penetrate
B	Bravo	Visible evidence of a crevice along the margin of the sealant that the explorer could penetrate
2. Sealant retention		
A	Alfa	Complete retention
B	Bravo	Partial retention
C	Charlie	No retention
3. Fissure caries		
A	Alfa	Sound fissures
B	Bravo	Fissures with caries
4. Surface roughness		
A	Alfa	The sealant surface is similar to polished enamel
B	Bravo	The sealant surface is similar to composite material surface contained submicron filler
C	Charlie	The surface is so rough that prevents the explorer movement along the surface
5. Change of colour around the sealant		
A	Alfa	No discoloration anywhere on the margin around the sealant
B	Bravo	Visible partial discoloration on the margin around the sealant
C	Charlie	Visible discoloration on the margin around all sealant

The pits and fissures were more vulnerable to caries development. In the group of 7-8-year-olds, 83.3% of all carious lesions in permanent teeth occurred in pits and fissures. In the 12-13-years-old group, 65% of caries increment was registered on occlusal surfaces of teeth.

At the beginning of the trial, an insufficient level of oral hygiene was diagnosed in both groups and the PHP Index value was 2.70±0.06 and 2.40±0.09 in 7-8 and in 12-13-year-olds, respectively. After 12 months, there was a significant (P<0.001) decrease in the PHP Index values to 2.1±0.05 (in 7-8-year-olds) and 1.8±0.06 (in 12-13-year-olds)

The results of sealant evaluation at 3, 6, and 12 months after a single application are presented in *Table 2*.

In the initial period (three months after sealant application), there were defects (such as poor marginal adaptation and partial sealant loss) in two (3.2%) children from the first group and one (1.5%) from the second. Complete retention was seen in 57 permanent first molars (90.5%) and 60 second molars (92.3%), and partial retention in 9.5% and 7.7%, respectively.

The examination carried out after six months showed that three (4.8% and 4.6%) sealants in each group had defective margins. The sealants were intact in 56 (88.9%) first molars and 59 (90.8%) second molars; partial retention was detected in seven (11.1%) and six (9.2%) teeth, respectively. No tooth had complete sealant loss during this period of time. One (1.6%) first molar from the 7-8-years-old group and two (3.1%) second molars from the group of 12-13-year-olds had surface roughness. The same number of teeth had visible partial change of colour around the sealant.

The results after one year showed that there were marginal defects in five (7.9%) teeth in the first group and six (9.2%) in the second group. The number of teeth with surface roughness increased to seven (11.1%) and eight (12.3%) in the first and second groups, respectively. There was visible partial change of colour around four (6.3%) sealants in permanent first molars and around five (7.7%) in permanent second molars.

Thus after 12 months, 54 (85.7%) first molars in the 7-8-years-old group and 58 (89.2%) second molars in the group of 12-13-year-olds were fully sealed whereas seven (11.1%) and six (9.2%) were partially sealed. The sealant was completely missing from two (3.2%) first molars and one (1.5%) second molar.

The retention rate appeared to be better in mandibular teeth: 77.8% of sealant loss was in the

Table 2. *Percentage of teeth with Esterfill Ca/F sealant*

	3 months				6 months				12 months			
Age	**7-8 years**		**12-13 years**		**7-8 years**		**12-13 years**		**7-8 years**		**12-13 years**	
Number of sealed teeth	63		65		63		65		61		64	
1. Marginal adaptation												
	n	%	n	%	n	%	n	%	n	%	n	%
Alfa												
Bravo												
	61	96.8	64	98.4	60	95.2	62	95.4	56	88.9	58	89.2
	2	3.2	1	1.6	3	4.8	3	4.6	5	7.9	6	9.2
2. Sealant retention												
	n	%	n	%	n	%	n	%	n	%	n	%
Alfa												
Bravo												
Charlie												
	57	90.5	60	92.3	56	88.9	59	90.8	54	85.7	58	89.2
	6	9.5	5	7.7	7	11.1	6	9.2	7	11.1	6	9.2
	0	-	0	-	0	-	0	-	2	3.2	1	1.5
3. Fissure caries												
	n	%	n	%	n	%	n	%	n	%	n	%
Alfa												
Bravo												
	63	100	65	100	63	100	65	100	63	100	65	100
	0	-	0	-	0	-	0	-	0	-	0	-
4. Surface roughness												
	n	%	n	%	n	%	n	%	n	%	n	%
Alfa												
Bravo												
Charlie												
	63	100	65	100	62	98.4	63	96.9	54	85.7	56	86.2
	0	-	0	-	1	1.6	2	3.1	7	11.1	8	12.3
	0	-	0	-	0	-	0	-	0	-	0	-
4. Change of colour around the sealant												
	n	%	n	%	n	%	n	%	n	%	n	%
Alfa												
Bravo												
Charlie												
	63	100	65	100	62	98.4	63	96.9	57	90.5	59	90.8
	0	-	0	-	1	1.6	2	3.1	4	6.3	5	7.7
	0	-	0	-	0	-	0	-	0	-	0	-

Table 3. *Percentage of teeth with caries development in sealed and control teeth*

	Children age	Number of teeth	After 3 months		After 6 months		After 12 months	
			n	%	n	%	n	%
Esterfill Ca/F	7-8 years	63	0	-	0	-	0	-
	12-13 years	65	0	-	0	-	0	-
Control teeth	7-8 years	42	0	-	2	4.8	5	11.9
	12-13 years	42	0	-	4	9.5	6	14.3

maxillary teeth of 7-8-year-olds and 71.4% in the mandibular teeth of 12-13-year-olds.

At the end of the study, not one sealed occlusal surface including teeth with partial or total sealant loss had carious lesions, whereas five (11.9%) control first molars and six (14.3%) control second molars had developed caries *(Table 3).*

Discussion

Development and improvement of fluoride-releasing composite resins is ongoing because there is a need for polymer matrix modification in order to maintain physical properties, water absorption reduction and long-term fluoride release [17].

It appeared that the level of fluoride release from composite resins with bioactive glass was greater than that from conventional ones and some compomers [18,19]. Moreover, they have an ability to release calcium over a long period [20], which also promotes mineralisation of tooth enamel.

However intensive ion diffusion from composite resin into the local tooth environment impairs physical and mechanical material properties and reduces its resistance to abrasion [20,21].

Esterfill Ca/F sealant containing bioactive glass has never been clinically studied. A previous laboratory investigation showed that use of bioactive glass as a filler for Esterfill Ca/F did not alter its strength, adhesive, and aesthetic properties. These factors were comparable to those of conventional composite material, suggesting the possibility of good results in clinical use [22].

The present research data demonstrate excellent complete retention of Esterfill Ca/F on occlusal surfaces of children's teeth and are comparable with studies of fluoride-releasing sealants and their full retention of 65-87% after one year [13,23,24]. Better retention of fluoride-containing sealants has been demonstrated after the use of a minimal enamel reduction technique of the occlusal fissures before its application [25,26].

One-year results showed a small difference in marginal adaptation, roughness, and colour change around the sealant between two groups of children. Partial material loss, especially from shallow fissures and distal fissures of upper molars, as well as sealant roughness were the most frequent defects after 12 months.

Better retention rate of the fissure sealant was diagnosed in mandibular teeth compared with maxillary ones in 12-13-years-old children. The retention rate in their second molars was comparable with figures found in the first molars of the younger children. In our opinion, sealant roughness was related to material solubility connected with fluoride and calcium release.

In both groups, sealing of pits and fissures with Esterfill Ca/F provided caries protection in 100% of teeth, including molars with partial sealant loss and disorder of marginal adaptation. Long-term observation of these defects revealed partial marginal discoloration around the sealant.

It can be concluded that it is essential to perform an early examination of children after sealant application in order to eliminate these defects as soon as possible.

Around 11.9% (the 7-8-years-old group) and 14.3% (the 12-13-year-old group) of the control teeth developed caries over one year but no sealed teeth did, in spite of the children's caries experience and their insufficient oral hygiene. Therefore sealing of nearly erupted molars was effective in pit-and-fissure caries prevention.

Conclusion

In the groups of children studied, it can be concluded that:

● After one year, fissure sealant containing bioactive glass had good retention rates with less than 3% total sealant loss.

● The sealant was effective in prevention of pit-and-fissure caries.

● There was no sign of caries development on occlusal surfaces where the sealant had been completely or partially lost.

References

1. Paynter KJ, Grainger RM. Relationship of morphology and size of teeth to caries. *International Dental Journal* 1962; **12**: 147-160.

2. Binus W, Czerepak C, Stiefel A. Zum Reifegrad des Fissurenschmelzes durchbrechender Zahne [The maturity of fissures in erupting teeth] [Article in German]. *Zahn-, Mund- und Kieferheilkunde mit Zentralblatt* 1987; **75**: 657-664.

3. Carvalho JC, Ekstrand KR, Thylstrup A. Dental plaque and caries on occlusal surfaces of first permanent molars in relation to stage of eruption. *Journal of Dental Research* 1989; **68**: 773-779.

4. Kouzmina IN. Prevention of initial caries during eruption of permanent teeth. [dissertation]. Moscow: Moscow State University of Medicine and Dentistry; 1996.

5. Romcke RG, Lewis DW, Maze BD, Vickerson RA. Retention and maintenance of fissure sealants over 10 years. *Journal of the Canadian Dental Association* 1990; **56**: 235-237.

6. Simonsen RJ. Retention and effectiveness of a dental sealant after 15 years. *Journal of the American Dental Association* 1991; **122**: 34-42.

7. Wendt LK, Koch G, Birkhed D. On the retention and effectiveness of fissure sealant in permanent molars after 15-20 years: a cohort study. *Community Dentistry and Oral Epidemiology* 2001; **29**: 302-307.

8. Lee H, Stoffey D, Orolowski J, Swartz ML, Ocumpaugh D, Neville K. Sealing of developmental pits and fissures. Effects of fluoride on adhesion of rigid and flexible sealers. *Journal of Dental Research* 1972; **51**: 191-201.

9. Pugnier VA. Cyanoacrylate resins in caries prevention: a two-year study. *Journal of the American Dental Association* 1972; **84**: 829-831.

10. Bowen RL. The properties of a silica reinforced polymer for dental restorations. *Journal of the American Dental Association* 1963; **66**: 57-64.

11. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. *Journal of Dental Research* 1955; **34**: 849-853.

12. Hicks J, Garcia-Godoy F, Donly K, Flaitz C. Fluoride-releasing restorative materials and secondary caries. *Journal of the California Dental Association* 2003; **31**: 229-245.

13. Jensen OE, Billings RJ, Featherstone JD. Clinical evaluation of Fluroshield pit and fissure sealant. *Clinical Preventive Dentistry* 1990; **12**: 24-27.

14. Heifetz SB, Yaari A, Proskin H. Anticaries effectiveness of a fluoride and nonfluoride sealant. *Journal of the California Dental Association* 2007; **35**: 573-577.

15. Welbury R, Raadal M, Lygidakis NA. EAPD guidelines for the use of pit and fissure sealants. *European Journal of Paediatric Dentistry* 2004; **5**: 179-184.

16. Ryge G. Clinical criteria. *International Dental Journal* 1980; **30**: 347-358.

17. Glasspoole EA, Erickson RL, Davidson CL. A fluoride-releasing composite for dental applications. *Dental Materials* 2001; **17**: 127-133.

18. Peng D, Smales RJ, Yip HK, Shu M. *In vitro* fluoride release from aesthetic restorative materials following recharging with APF gel. *Australian Dental Journal* 2000; **45**: 198-203.

19. Attar N, Turgut MD. Fluoride release and uptake capacities of fluoride-releasing restorative materials. *Operative Dentistry* 2003; **28**: 395-402.

20. Frankenberger R, García-Godoy F, Lohbauer U, Petschelt A, Krämer N. Evaluation of resin composite materials. Part I: *in vitro* investigations. *American Dental Journal* 2005; **18**: 23-27.

21. Xu X, Burgess JO. Compressive strength, fluoride release and recharge of fluoride-releasing materials. *Biomaterials* 2003; **24**: 2451-2461.

22. Pazdnikova NK, Kouzmina IN, Benya VN, Polikarpova AP, Grigoryev AG. Comparative evaluation of physical, adhesive and aesthetic properties of light-cured sealants contained fluoride and calcium. *Dental Forum* 2008; **3**: 18-23.

23. Morphis TL, Toumba KJ. Retention of two fluoride pit-and-fissure sealants in comparison to a conventional sealant. *International Journal of Paediatric Dentistry* 1998; **8**: 203-208.

24. Benya VN. Prevention of occlusal caries of permanent teeth in children and adolescents [dissertation]. Moscow: Moscow State University of Medicine and Dentistry; 2006.

25. Lygidakis NA, Katsaris N, Morphis T, Oulis CJ. A two year clinical trial comparing two different F releasing fissure sealants. *European Journal of Paediatric Dentistry* 2000; **1**: 171-177.

26. Lygidakis NA, Oulis KI, Christodoulidis A. Evaluation of fissure sealant retention following four different isolation and surface preparation techniques: four years clinical trial. *Journal of Clinical Paediatric Dentistry* 1994; **19**: 23-25.