

Evaluation of the Clinical Success of Fissure Sealants Applied to Young Permanent Teeth

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ABSTRACT

Aim: The success of a fissure sealant (FS) is usually measured with maintained retention, but it is reported that even if the FS is completely lost, the caries prevention effect may continue. The aim of the study was to evaluate clinical success of a fissure sealant according to the type, localization of applied teeth and the follow-up time and also determine the clinical success of the FS according to retention and caries prevalence.

Material and Methods: Children whose permanent premolar and/or molar teeth were treated with a fluoride-releasing resin-containing FS (Clinpro Sealant™, 3M ESPE, St. Paul, MN, USA) were invited for control. The clinical success of FS was evaluated by modified USPHS criteria and the data were analyzed by Chi-square test.

Results: In total, 1272 FS were examined for 2, 3 or 4 years. There was no significant relationship between the follow-up time and retention rates ($p=0.150$). Marginal discoloration, marginal adaptation and retention scores were significantly more successful in premolars ($p\leq 0.05$). The rates of caries in premolars and molars were 0.5% and 0% in FS with full-retention, 14.2% and 25.7% in FS with partial-retention, and 6.2% and 11.2% in FS with total loss, respectively.

Conclusion: Full retention ensures the highest caries prevention. However, FS that have been completely lost are still effective in preventing caries and their success is higher than FS with partial retention. It is important to apply fissure sealants to permanent molars and premolars in every possible child to ensure their oral health in the future.

Genç Daimi Dişlere Uygulanan Fissür Örtücülerin Klinik Başarısının Değerlendirilmesi

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ÖZET

Amaç: Fissür örtücülerin (FÖ) başarısı genellikle retansiyonuyla ölçülmektedir ancak FÖ tamamen kaybolursa bile çürük önleyici etkisinin devam edebileceği bildirilmektedir. Bu çalışmanın amacı fissür örtücülerin klinik başarısını, uygulanan dişlerin tipine, lokalizasyonuna ve takip süresine göre değerlendirmek, ayrıca retansiyon ve çürük prevalansına göre fissür örtücünün klinik başarısını belirlemektir.

Gereç ve Yöntemler: Daimi küçük azı ve/veya büyük azı dişlerine, florid salgılayan rezin içerikli FÖ (Clinpro Sealant™, 3M ESPE, St. Paul, MN, ABD) uygulanmış olan çocuklar kontrol için kliniğe davet edilmiştir. FÖ'nün klinik başarısı, modifiye USPHS kriterleri ile değerlendirilmiştir ve veriler Ki-kare testi ile analiz edilmiştir.

Bulgular: Toplamda 1272 FÖ 2, 3 veya 4 yıl süreyle incelenmiştir. Takip süresi ile retansiyon oranları arasında anlamlı bir ilişki bulunamamıştır ($p=0,150$). Kenar renklemesi, kenar adaptasyonu ve retansiyon skorlarının küçük azı dişlerinde anlamlı olarak daha başarılı olduğu tespit edilmiştir ($p\leq 0,05$). Küçük azı ve büyük azı dişlerinde çürük oranları tam retansiyonlu FÖ'de %0,5 ve %0, kısmi retansiyonlu FÖ'de %14,2 ve %25,7 total kayıplı FÖ'de ise sırasıyla %6,2 ve %11,2 olarak belirlenmiştir.

Sonuç: Tam retansiyon en yüksek çürük önlemeyi sağlamaktadır. Ancak, tamamen kaybedilen FÖ'ler çürük önlemede hala etkilidir ve başarıları kısmi retansiyonlu FÖ'e göre daha yüksektir. Gelecekte ağız ve diş sağlığını sağlayabilmek için, mümkün olan her çocuğun daimi azı dişlerine fissür örtücü uygulanması önemlidir.

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INTRODUCTION

In recent years, thanks to fluoride, the incidence of tooth decay in the child and adolescent population has decreased compared to the past. However, the risk of caries formation on occlusal surfaces is still high in this age group. Covering the surface with various materials is one of the most effective methods known to protect the posterior teeth from pit and fissure caries where almost half of all caries occurs.¹⁻⁴ Fissure sealants are used to prevent the development of bacteria that cause caries in the fissures of posterior teeth. Resin-based sealants and glass ionomer based sealants are the two most common types.⁵ Fissure sealants which were first developed in the 1960s, were produced in many different types with the changes made in the material content or the setting mechanism, and finally, materials releasing fluoride were produced.⁶ It is known that regardless of its content and setting type, fissure sealants have achieved significant success in preventing bacterial retention in deep pits and fissures and mineral loss of tooth surfaces against acid attacks.⁷ Therefore, fissure sealants are known as a valuable strategy to prevent the development of caries in permanent molars.⁸

Failure of fissure sealants is most common in the first year following the application, and failure rates increase when the follow-up period becomes longer.⁹ Fissure sealants, in which the technique is applied meticulously, are desired to remain in fissures for a long time without deterioration or need to be repeated. There are studies reporting that there is a significant difference between the maxilla and mandible in the retention success of fissure sealants, and that there is a significant difference between the right and left sides of the jaws in terms of the success of fissure sealants.^{10,11} To the contrary, a published review reported that the localization of fissure sealants had no effect on the success of fissure sealants.¹² According to some authors, a fissure sealant's clinical success is achieved by the continuation

of full retention in fissures.^{13,14} On the other hand, some authors reported that even if the fissure sealant has been clinically lost, the resin extensions placed on the roughened enamel surface, which can be observed microscopically, continue to protect the tooth tissues from demineralization.¹⁵ In addition, Hevinga et al.¹⁶ reported that tooth type and patient restoration profile are determinants of the long-term success of resin fissure sealants. These different opinions in the literature suggest the question of whether the determinant factor in the clinical success of fissure sealants is retention or the absence of caries.

The aim of the study was to evaluate the long-term clinical success of a fluoride-releasing resin-containing fissure sealant according to the type, localization of applied teeth and the follow-up time based on their caries prevention ability and retention. Secondly this study aimed to determine whether the main determinant in the clinical success of FS is the retention or caries prevention ability.

MATERIAL AND METHODS

This study has been reviewed and approved by the Ethical Committee of Pamukkale University, Faculty of Medicine and all the procedures performed in the study were performed in accordance with the ethical standards given in the Declaration of Helsinki.

Study Design

The records of all healthy children whose fully erupted permanent premolar and/or molar teeth were treated non-invasively with a fluoride-releasing resin-containing fissure sealant (Clinpro Sealant™, 3M ESPE, St. Paul, MN, USA) by the same physician (H.Ö.İ.) in a pediatric dentistry clinic between January 2015 and December 2018, were reviewed retrospectively. Patients were called by phone and invited to the clinic for a follow-up appointment. All patients who could be reached at the time of the study (from January 2019 to December 2020) and who could attend the

control appointment were included in the study. At the control visits, the children's demographic data, tooth brushing habits and clinical examination findings were recorded in the anamnesis forms. As a result of clinical and radiographical examinations, the number of teeth affected by dental caries was determined by using the DMFT/dmft index and the presence of microbial dental plaque was determined with the Simplified Oral Hygiene Index.^{17,18}

Clinical Assessment

Clinical examination of all fissure sealants was performed by the same trained and calibrated dentist (F.S.) under reflector light. The examiner was calibrated with an experienced examiner. The teeth were dried and examined with a dental mirror and blunt probe. The clinical success of fissure sealants were evaluated by modified United States Public Health Service (USPHS) clinical rating system.¹⁹ Scoring was made according to marginal discoloration, marginal adaptation, retention, surface texture and caries criteria.

Statistical Analysis

The statistical analyses were performed by using IBM SPSS Software (SPSS v 23.0; SPSS Inc., Chicago, IL, USA). Descriptive analyses were used in the statistical analysis of the data and the Chi-square analysis were used

to examine the differences between categorical variables at the significance level of $p \leq 0.05$.

RESULTS

In the study, 1272 fissure sealants in 208 (114 girls, 94 boys) children who could come for the control examination were evaluated. The intra-examiner reliability for retention and caries criteria were high, with kappa values of 0.95 and 0.93, respectively. The mean age of the children at the control visit was 13.42 ± 2.61 . In the fissure sealant groups followed for 2, 3 and 4 years, the mean ages of the children were 11.28, 12.75 and 13.92, respectively. It was learned that 80.7% of the children brush their teeth at least once a day and 94.7% of them use fluoride paste. The mean plaque index score of all children participating in the study was 0.69 ± 0.47 and the mean DMFT/dmft index score was 3.38 ± 3.01 .

The mean number of fissure sealants applied to each patient was 6.40 ± 4.00 and 659 of the examined fissure sealants were applied to premolar teeth and 613 to molar teeth (Table 1). Of the examined fissure sealants, 205 were followed for 2 years, 415 for 3 years, and 652 for 4 years (Table 1). The average follow-up period was 40.10 ± 8.72 months (Table 1). The distribution of the FS according to the type and localization of the applied teeth and the follow-up time are given in Table 1.

Table 1. Distribution of the FS according to type and localization of applied teeth and the follow-up time

FS applied teeth	Follow-up time			Total n
	2 years n	3 years n	4 years n	
Upper right premolar	26	65	83	
Upper left premolar	27	62	75	
Lower left premolar	30	51	85	
Lower right premolar	31	51	73	
Total number of premolar	114	229	316	659
Upper right molar	21	58	83	
Upper left molar	20	53	81	
Lower left molar	24	36	88	
Lower right molar	26	39	84	
Total number of molar	91	186	336	613
Total number of teeth	205	415	652	1272

FS: fissure sealant. n: number of teeth.

The differences in the clinical success of the fissure sealants are shown in Tables 2, 3 and 4 according to the follow-up time. Marginal discoloration ($p=0.005$; $p=0.000$; $p=0.000$), marginal adaptation ($p=0.000$; $p=0.000$; $p=0.000$) and retention ($p=0.000$; $p=0.000$; $p=0.000$) scores were significantly more successful in premolars than in molars at all follow-up periods (Table 2, 3, 4). It was observed that the surface texture score did not differ significantly ($p=0.855$; 0.322) between the fissure sealants applied to the premolar and

molar teeth during 3- and 4-year follow-up periods (Table 3, 4). Caries score was significantly more successful ($p=0.031$; $p=0.002$) in premolars than in molars at 2- and 3-year follow-up periods (Table 2, 3). In addition, there was no significant relationship between the follow-up time of the FS and clinical performance (marginal adaptation $p=0.177$; retention $p=0.150$; surface texture $p=0.382$; caries $p=0.759$) either premolars or molars except marginal discoloration (2/3 year $p=0.006$; 2/4 year $p=0.05$; 3/4 year $p=0.560$).

Table 2. Differences in the clinical success of FS followed for 2 years according to the type and localization of the applied tooth

USPHS criteria	Comparison criteria	Statistical significant difference	p value
Marginal discoloration	Upper-lower jaw	No	$p=0.252$
	Right-Left jaw	No	$p=0.340$
	Premolar-molar	FS applied to premolars are more successful	$p=0.005$
Marginal adaptation	Upper-lower jaw	No	$p=0.138$
	Right-Left jaw	No	$p=0.944$
	Premolar-molar	FS applied to premolars are more successful	$p=0.000$
Retention	Upper-lower jaw	No	$p=0.124$
	Right-Left jaw	No	$p=0.763$
	Premolar-molar	FS applied to premolars are more successful	$p=0.000$
Surface texture	Upper-lower jaw	No	$p=1.000$
	Right-Left jaw	No	$p=0.871$
	Premolar-molar	FS applied to premolars are more successful	$p=0.038$
Caries	Upper-lower jaw	No	$p=0.328$
	Right-Left jaw	No	$p=0.621$
	Premolar-molar	FS applied to premolars are more successful	$p=0.031$

FS: fissure sealant. USPHS: United States Public Health Service clinical rating system. Those with $p \leq 0.05$ show statistically significant difference.

Table 3. Differences in the clinical success of FS followed for 3 years according to the type and localization of the applied tooth

USPHS criteria	Comparison criteria	Statistical significant difference	p value
Marginal discoloration	Upper-lower jaw	No	$p=0.750$
	Right-Left jaw	No	$p=0.950$
	Premolar-molar	FS applied to premolars are more successful	$p=0.000$
Marginal adaptation	Upper-lower jaw	No	$p=0.861$
	Right-Left jaw	No	$p=0.466$
	Premolar-molar	FS applied to premolars are more successful	$p=0.000$
Retention	Upper-lower jaw	No	$p=0.905$
	Right-Left jaw	No	$p=0.649$
	Premolar-molar	FS applied to premolars are more successful	$p=0.000$
Surface texture	Upper-lower jaw	No	$p=0.920$
	Right-Left jaw	No	$p=0.062$
	Premolar-molar	No	$p=0.855$
Caries	Upper-lower jaw	No	$p=0.601$
	Right-Left jaw	No	$p=1.000$
	Premolar-molar	No	$p=0.002$

FS: fissure sealant. USPHS: United States Public Health Service clinical rating system. Those with $p \leq 0.05$ show statistically significant difference.

Table 4. Differences in the clinical success of FS followed for 4 years according to the type and localization of the applied tooth

USPHS criteria	Comparison criteria	Statistical significant difference	p value
Marginal discoloration	Upper-lower jaw	Upper right molars more successful than lower right molars	p=0.000
	Right-Left jaw	No	p=0.358
	Premolar-molar	FS applied to premolars are more successful	p=0.000
Marginal adaptation	Upper-lower jaw	No	p=0.294
	Right-Left jaw	No	p=0.831
	Premolar-molar	FS applied to premolars are more successful	p=0.000
Retention	Upper-lower jaw	No	p=0.437
	Right-Left jaw	No	p=0.685
	Premolar-molar	FS applied to premolars are more successful	p=0.000
Surface texture	Upper-lower jaw	FS applied to lower jaw are more successful	p=0.045
	Right-Left jaw	No	p=0.750
	Premolar-molar	No	p=0.322
Caries	Upper-lower jaw	No	p=0.291
	Right-Left jaw	No	p=0.224
	Premolar-molar	No	p=0.072

FS: fissure sealant. USPHS: United States Public Health Service clinical rating system. Those with $p \leq 0.05$ show statistically significant difference.

The full retention rates in premolars and molars were 91.2% and 62.8% in cases with 2-year follow-up, 89.2% and 80.1% in cases with 3-year follow-up, and 92.2% and 72.6% in cases with 4-year follow-up, respectively (Table 5). The rates of caries in premolars and molars were 0.5% and 0% in FS with full retention, 14.2%

and 25.7% in FS with partial retention, and 6.2% and 11.2% in those with total FS loss, respectively. (Table 6) The mean DMFT/dmft value of the cases with complete FS loss and caries was found to be 4, of the cases with partial FS loss and caries was 4.55, and of the cases with complete FS retention and caries was 7.

Table 5. Retention rates of fissure sealants

Follow up time	Premolar			Molar		
	Complete retention (Oscar*) n(%)	Partial retention (Bravo/Charlie*) n(%)	Complete loss (Delta*) n(%)	Complete retention (Oscar*) n(%)	Partial retention (Bravo/Charlie*) n(%)	Complete loss (Delta*) n(%)
2 years	104 (91.2%)	5 (4.38%)	5 (4.38%)	57 (62.8%)	23 (25.2%)	11 (12%)
3 years	204 (89.2%)	12 (5.2%)	13 (5.6%)	149 (80.1%)	27 (14.5%)	10 (5.4%)
4 years	291 (92.2%)	11 (3.4%)	14 (4.4%)	244 (72.6%)	51 (15.2%)	41 (12.2%)

* Retention scores according to USPHS criteria²¹ Oscar: Harmonious and continuous with occlusal form and structure. Bravo: Loss of sealant from one or two pits or accessory grooves (partial loss) but not requiring repair or replacement of the sealant. Charlie: Loss of sealant from pits or accessory grooves (partial loss), requiring a replacement or a repair of the sealant. Delta: Loss of sealant from all pits (total loss).

Table 6. The rates of caries based on retention scores of fissure sealants

Follow up time	Complete retention (Oscar*)		Partial retention (Bravo/Charlie*)		Complete loss (Delta*)	
	Caries		Caries		Caries	
	Premolar n(%)	Molar n(%)	Premolar n(%)	Molar n(%)	Premolar n(%)	Molar n(%)
2 years	0(0%)	0 (0%)	0 (0%)	4 (17.3%)	0 (0%)	0 (0%)
3 years	1(0.4%)	0 (0%)	1(8.3%)	11 (40.7%)	1 (7.6%)	1 (10%)
4 years	2(0.6%)	0 (0%)	3 (27.2%)	11(21.5%)	1 (7.1%)	6 (14.6%)

* Retention scores according to USPHS criteria²¹ Oscar: Harmonious and continuous with occlusal form and structure. Bravo: Loss of sealant from one or two pits or accessory grooves (partial loss) but not requiring repair or replacement of the sealant. Charlie: Loss of sealant from pits or accessory grooves (partial loss), requiring a replacement or a repair of the sealant. Delta: Loss of sealant from all pits (total loss).

DISCUSSION

Fissure sealants are known as a valuable strategy to prevent the development of caries in permanent molars and they have been the subject of many clinical studies in the field of pediatric dentistry.⁸ Although fissure sealants are expected to fulfill their function by remaining in fissures for a long time without breaking or falling, losses may occur over time.^{10,11} This study aimed to determine whether the main determinant in the clinical success of FS is the retention or caries prevention ability and to evaluate the long-term clinical success of a fluoride-releasing resin-containing fissure sealant.

Since the success of fissure sealants may not be standardized when applied by different operators, our study was carried out with fissure sealants performed by a single operator. Similarly, since differences may be observed when the clinical controls of fissure sealants are performed by different operators, in our study all fissure sealants were controlled by a single operator. There was no significant relationship between the follow-up time and retention rates of the fissure sealants, so it is inconsistent with the opinion that retention rates will decrease as the follow-up period increases.¹² The fact that, better retention scores were not obtained in FS followed for 2 years or worse scores were not obtained in FS followed for 4 years, supports the view that a meticulously performed FS can remain in fissures for many years.¹⁶

There was no significant difference between the fissure sealants on the right or left sides of the jaws in any evaluation criteria during all follow-up periods. Among the fissure sealants applied in the lower and upper jaws, it was observed that the marginal discoloration score showed better results in the upper molars than the lower molars in cases followed for 4 years. These results are compatible with the data in the literature.¹²

In the present study, in regard to

marginal discoloration, marginal adaptation and retention, fissure sealants applied to premolar teeth were statistically significantly more successful than those applied to molar teeth in all follow-up periods. Similarly, it is stated in the studies conducted on this subject that the retention of fissure sealants applied to premolars is more successful.^{12,20} It is stated that the reason for this result is not the differences in the anatomical structure of the teeth, but the doubling of the risk of failure due to the doubling of the total fissure sealant area and the amount of applied material in the molar teeth.^{20,21}

In some studies, it is stated that the protective effect of the fissure sealant is provided by the continuation of the retention of the resin to the fissures.^{5,22} It has been shown that even after the total loss of resin fissure sealants with or without fluoride release, residues of the resin remaining in the tags can continue to protect the enamel from decay.¹⁵ In this study, caries rates in FS that were totally lost were 6.2% and 11.2% in premolars and molars, respectively. These rates are lower than the incidence of dental caries reported in posterior teeth that have never been treated with fissure sealant before.^{23,24} It would be more accurate to compare the prevalence of caries in teeth with complete FS loss with teeth that have never had FS before in the same mouth. However, since it would not be ethical to consciously not apply FS to some teeth of children, a comparison was made with the data of caries prevalence studies conducted in the same age groups. Therefore, according to the results of this study, it is thought that even if the FS is visibly completely removed from the surface, its protective effect against dental caries may continue. This finding is parallel to the results of a similar study conducted previously.²⁵ It is stated that the reason for less decay formation in premolars, both at the margins of the FS and following total loss, is not due to the high protective ability of the material

in these teeth, but it is because the incidence of tooth decay in premolars is already lower than molars, although without FS.^{23,26}

Some studies report that teeth with partially or completely lost fissure sealants do not have a higher risk of developing caries compared to unsealed teeth. It is concluded that fissure sealants are indicated even if regular follow-up is not possible.^{25,27} On the other hand, some studies have reported that fissure sealants should be checked regularly and reapplied if found defective. They concluded that incompletely sealed fissures are at higher risk for caries development compared to fully sealed teeth.^{12,28} Retention rate is considered to be an accurate determinant of the success of sealants in caries prevention.^{29,30} Rock and Anderson³¹ clearly emphasized that the effects of fissure sealants continue only while they are present on the teeth. Authors noted that fissure sealant retention must be completely intact if any prophylactic benefit is to be achieved.^{30,32,33} However, Mickenautsch et al.^{34,35} stated that the retention rate is not an accurate determinant for the success of sealants in caries prevention. They noted that after losing retention, fissures may still contain microseal residues. This may be because fissure sealants seal pits and fissures through micro-retention created via resin tags after enamel etching. It is reported that complete retention of fissure sealants has been established as a beneficial factor in preventing the teeth. However the retention of fissure sealants is not a valid predictor for clinical success.^{34,35} Another problem with partially or completely lost fissure sealants is that they can leave sharp edges that cause food accumulation and ultimately lead to decay.³⁶ A systematic review assessed whether the risk of developing caries in teeth with partial or complete loss of sealant exceeded the risk in teeth that have never been sealed. It has been found that teeth that have partially or completely lost their sealant do not have a higher risk of developing caries than teeth that have never been sealed.^{25,37} Ostrc et

al.³⁸ reported similar findings which are parallel to present study. They indicated that incompletely sealed molars did not protect the teeth efficiently.

Compared to no sealant use, fissure sealant is an effective and valuable method against the caries.²⁴ American Academy of Pediatric Dentistry concluded that fissure sealants are effective in preventing and arresting pit-and-fissure occlusal carious lesions of primary and permanent molars in children and adolescents compared with the non-use of sealants.³⁹ It is reported that preventive effect of fissure sealants ranges from 87% at 12 months to 60% at 48-54 months.⁴⁰ However, the protective properties of fissure sealants are to some extent.⁴¹ Regular check of sealed teeth is important, and if it is detected to be removed, reapplication of fissure sealant should be reapplied.³⁸ However, the fact that the child cannot attend the next appointments should not be the reason for the dentist not to apply fissure sealants.²⁵

In the present study, teeth with FS were included in the study regardless of their occlusion type. The occlusion type of the teeth and whether they participate in chewing function may affect the retention of fissure sealants. In addition, the presence of a fissure sealant or restoration on the opposing tooth and the type of this restoration may also affect the retention of fissure sealants. This situation can be considered as a limitation of the study and new studies can be planned by taking it into consideration in future studies.

In this study, an answer was sought to the question of whether 'fissure sealant retention' or 'prevention of caries that cause the need for restoration' is the main determinant in the clinical success of FS. According to the data obtained, the caries preventive effect of a fissure sealant, is highest in the case of complete retention. However, it was observed that the rate of caries observed in fissure sealants with partial loss was higher than that in teeth with

complete FS loss, and the DMFT/dmft scores of the patients in these two groups were similar. This result may be attributed to two reasons. The first is that the FS remaining partially on the fissures creates a suitable ground for caries by creating a retention area for bacteria and food residues, and the second is that the FS that is completely loss may continue to protect the tooth surface against demineralization.

CONCLUSION

In this study, it was determined that tooth type, localization and follow-up period do not have a significant effect on the clinical success of fissure sealants. The clinical success of fissure sealants should be measured by the continuation of caries prevention efficacy. It has been found that complete retention provides the highest success for caries prevention efficacy; however, fissure sealants with complete loss also continue to have this effect and are more successful than fissure sealants with partial retention. This article clarified the effect of the retention status of resin fissure sealants on their preventive efficacy and showed that the anti-caries effect of resin fissure sealants may continue even if they are completely lost.

Ethical Committee Approval

The required ethical approval for this study was received from Pamukkale University Faculty of Medicine Non-Drug and Medical Device ethics committee (2020/01).

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Conflict of Interest

The authors deny any conflicts of interest related to this study.

Author Contributions

Design: CÇE, HÖİ. Fissure sealant applications: HÖİ. Fissure sealant controls: FS. Literature review: CÇE, HÖİ. Analysis and writing: CÇE.

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