Sealant Retention in Pits and Fissures: Preparation and Application Techniques. A Literature Review

SUMMARY

The effectiveness of sealants as a preventive measure has been well established. However, the desirable successful outcome depends on retention and, therefore, on the factors contributing to this. The purpose of this literature review is to highlight the most significant factors connected with preparation and application of the sealant materials and any consensus that exists about their contribution to the longevity of the sealant. The preparation of the surface is a matter of great importance, the choice of the cleaning method before etching, and its relevance to retention, remains the subject of discussion. Techniques such as air abrasion, laser, and mechanical preparation have been proposed and applied with varying results. Application techniques are also a controversial area, especially when it comes to the use of self adhesive agents and special bonding agents. Other factors, however, have also been the subject of study in the literature. These include the state of eruption, the nature of isolation, type of the tooth, the profile of the operator and the kind of sealant. More long-term clinical trials are needed to examine the relationship between preparation and application process and retention in order to achieve the desired aim of improved clinical success rates.

Keywords: Pit Sealants; Fissure Sealants; Retention

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Introduction

Pits and fissures, forming part of occlusal tooth surfaces, are prone to decay or need for restoration in 70% of cases over a period of 10 years after eruption. Therefore, the need to use sealants in view of their ability to inhibit caries prevention has been underlined since the 1970s and 1980s. A significant consideration mentioned in the literature is that pits and fissures benefit less from fluoride due to their depth below the enamel surface and their close connection with dentin, and, therefore, are subject to rapid progression of caries. An important number of randomized clinical trials have confirmed their significance in caries prevention on occlusal surfaces. Every child or young person should be a candidate for using sealants when there are susceptible pits and fissures. The rationale of pit and fissure sealants is related to the fact that occlusal fissures are connected to the dentin and lesion can therefore spread along the enamel-dentin interface in a fast rate. Consequently, the effectiveness of sealants is well established for persons at high caries risk.

Retention still remains the main determinant factor for success, where this is defined in terms of long lasting protection, absence of open margins, and sound enamel of the occlusal surface. In other words, effectiveness and preventive ability is related to the complete retention of the material on the occlusal surfaces. Failure, on the other hand, is marked by an early loss, usually during the first year after application, mainly due to inadequate adhesion or by gradual failure of the sealant when exposed to wear. The statistics in the literature reveal a loss of 5-10% of sealant per year. With the endorsement of use of mainly resin-based materials for sealants, integration and retention has become the key for ensuring cariostatic effectiveness since such sealants present difficulties regarding the release of fluoride. In addition, good adaptation of the sealant can block micro-leakage and its detrimental impact on tooth integrity. Other research refers to retention in terms of “penetrability of the etched enamel, enough marginal...
sealing and resistance to wear\textsuperscript{15}. Taking into account that, micro-leakage does not necessarily mean loss of retention\textsuperscript{16}. Longevity, therefore, results from many factors contributing to better retention, such as fissure type, the kind of sealant, the profile of the operator, the nature of isolation, the type and place of the tooth, the enamel, eruption status and other factors\textsuperscript{2,17-21}. Notwithstanding the complexity of the issue, this review is an attempt to evaluate and report the most analyzed and important factors mentioned in the recent literature, focusing on preparation and application processes of sealant use.

**Preparation Technique**

**Cleaning Methods**

The importance of the method chosen for cleaning the surface is beyond question. Apart from conventional acid etching, other methods have been proposed and investigated. An early study suggested the lack of significant differences among the various selected cleaning methods in terms of the retention achieved\textsuperscript{22}. However, since then, newer techniques have been introduced and the need to evaluate their effect on retention still remains paramount.

One of the most emphasized factors discussed in the literature concerns the mechanical preparation of the surface, also termed enameloplasty or fissurotomy. In the light of the evidence provided, enameloplasty is not recommended, as a routine choice, before etching the tooth surface\textsuperscript{22,23}. This is consistent with Hatibovic-Kofman et al\textsuperscript{24}, who found no significant differences between mechanically prepared surfaces and those that had been only etched. Other extensive reviews of the literature also concluded that there was no strong supporting evidence in favour of enameloplasty\textsuperscript{23,24}. This view is supported by Fiegal and Donly\textsuperscript{26} who noted the lack of long-term clinical studies supporting enameloplasty, which could lead to its recommendation as a standard procedure. The European guidelines regarding pits and fissures suggest that excessive enlarging the fissures should be avoided since the literature does not relate high retention with the use of the bur\textsuperscript{27}.

However, on the same issue, evaluation of etch resistance in prismless walls of the enamel, it has been suggested that where pits are deeper, adequate etching might not be achieved, and thus, the prismless area of the walls should be removed\textsuperscript{28}. This is consistent with other authors who conclude that enameloplasty has a good effect on prismless enamel and enhances the bond to the surrounding enamel\textsuperscript{29}. In an in vitro study of a common sealant and preparation techniques, there were significantly better micro-leakage scores using enameloplasty, but significantly less advantage when it came to penetration\textsuperscript{30}. In addition, it has been suggested that bur preparation may remove accumulated debris from the deeper places in fissures\textsuperscript{22,31} and aids the exposure and removal of decayed areas\textsuperscript{32}. In the same double-blind study, it was also demonstrated that preparation resulted in better retention\textsuperscript{22}. Similarly, it was demonstrated that better penetration can be achieved by combination of enameloplasty and acid etching for a resinous sealant material when compared with the use of a compomer applied with a bonding agent but without preparation; therefore, this should be preferred clinically\textsuperscript{33}. This was attributed to better flow properties of the material in widened fissures\textsuperscript{34} and improved maintenance in cleaned cavities\textsuperscript{34}.

Another laboratory study also showed that mechanical preparation with a diamond-tapered bur led to better retention than with unprepared surfaces\textsuperscript{35}. These results are consistent with another study using an electron microscope to evaluate the enlargement of fissures\textsuperscript{31}. They suggested that the key to efficient bond is good penetration by the resin, which is facilitated by enameloplasty, and that enlargement enables more material to be applied, increasing resistance to loss. Their hypotheses were confirmed by microscope observations revealing superior adaptation levels and good retention patterns. This led them to propose the method for deep fissures.

It has also been proposed that mechanical fissure enlargement might be beneficial for maxillary molars\textsuperscript{22}. In addition when sealed fissures subject to enameloplasties were tested for micro-leakage, there were significant differences\textsuperscript{29}. Specifically, teeth with enameloplasty performed better under stress, with the type of bur affecting the result slightly in favour of the round bur against the tapered one\textsuperscript{29}.

Attempts to broaden the armory of techniques available for fissure preparation led to the creation of Carisolv system using sodium hypochlorite and 3 kinds of amino acids as chemical cleaning agents\textsuperscript{34}. This yielded smooth, normal surfaces, free of debris inside the cavity. These were somewhat rougher than brush-prepared surfaces, with no differences in micro-leakage between the 2 groups. However, possibility of achieving better retention with this type of chemical cleaning warrants further investigation.

A recent critical review of cleaning methods included only 2 clinical studies, finding no difference between cleaning with pumice and using water and a probe\textsuperscript{36}. The use of the probe is also supported clinically, but in terms of combining it with a bristle brush\textsuperscript{37}. Moreover, a literature search revealed that sealant retention was the same or higher after cleaning with a toothbrush in comparison with handpiece\textsuperscript{36}. Past practice recommended a prophy cup or bristle and pumice. It was then thought that any paste used should be fluoride free to avoid jeopardizing the enamel bond\textsuperscript{22}. However, more recent evidence seems to indicate that fluoride does not reduce retention ability\textsuperscript{26,36}. Nonetheless, recent guidelines do not recommend prophylaxis paste or pumice\textsuperscript{38}. Furthermore, an analysis has shown that handpiece-prophylaxis
recommendations about pits and fissure sealants concluded that there was no clear evidence about the air abrasion-acid combination\(^2\). Another study failed to find significant differences between the air abrasion and the pumice prophylaxis, when chosen as different procedures for testing sealant materials for leakage and success\(^4\). However, some researchers have found similar retention results between air-abrasion and the conventional acid etching\(^4, 46, 47\).

Comparison of sono-abrasion, acid etching and enameloplasty showed no significant differences between the 3 methods\(^4\).

The Er,Cr: YSGG laser system has also been suggested for surface preparation. In an \textit{in vitro} study\(^4\), acid etching, and the laser combined with acid etching performed similarly. In experiments to evaluate the shear bond strength of Er: YAG laser in the presence of saliva, the laser did not show comparable results to conventional etching with phosphoric acid\(^5\). On the same subject, other authors have found that applying a sealant to fissures after laser preparation resulted in greater micro-leakage than using mechanical preparation\(^3\) (Table 1).

<table>
<thead>
<tr>
<th>Study</th>
<th>Number of teeth</th>
<th>Cleaning/preparation method examined</th>
<th>Retention/microleakage of the sealants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geiger et al (2000)(^3)</td>
<td>90</td>
<td>Enameloplasty vs no mechanical preparation</td>
<td>Better retention rates (only 6.25% loss) for enameloplasty</td>
</tr>
<tr>
<td>Selecman et al (2007)(^5)</td>
<td>100</td>
<td>Pumice prophylaxis and air abrasion</td>
<td>No differences between them</td>
</tr>
<tr>
<td>Garcia-Godoy and de Araujo (1994)(^1)</td>
<td>32</td>
<td>Enameloplasty vs pumice prophylaxis</td>
<td>Better retention for enameloplasty</td>
</tr>
<tr>
<td>Lygidakis et al (1994)(^2)</td>
<td>320</td>
<td>Enameloplasty vs bristle brush with and without paste</td>
<td>Better retention for Enameloplasty</td>
</tr>
<tr>
<td>Burrow et al (2001)(^2)</td>
<td>55</td>
<td>Enameloplasty vs no mechanical preparation</td>
<td>Better retention for enameloplasty</td>
</tr>
<tr>
<td>Hatovic-Kofman et al (2001)(^2)</td>
<td>180</td>
<td>Enameloplasty vs air abrasion</td>
<td>Same retention</td>
</tr>
<tr>
<td>Yamada et al. (2008)(^3)</td>
<td>50</td>
<td>Preparation with Carisolv</td>
<td>Greater surface roughness, perhaps better retention</td>
</tr>
<tr>
<td>Knobloch et al., (2005)(^1)</td>
<td>40</td>
<td>Air abrasion</td>
<td>Better retention only together with acid etching</td>
</tr>
<tr>
<td>Salama and Al-Hammad (2002)(^3)</td>
<td>30</td>
<td>Enameloplasty vs no mechanical preparation</td>
<td>Better penetration for enameloplasty</td>
</tr>
<tr>
<td>Moslemi et al (2011)(^2)</td>
<td>45</td>
<td>Er,Cr: YSGG laser vs air abrasion</td>
<td>Better retention with air abrasion together with acid etching</td>
</tr>
<tr>
<td>Zervou et al (2000)(^2)</td>
<td>60</td>
<td>Enameloplasty vs no enameloplasty</td>
<td>Better microleakage scores for enameloplasty</td>
</tr>
<tr>
<td>Yazici et al (2006)(^4)</td>
<td>162</td>
<td>Air abrasion with acid etching vs acid etching alone</td>
<td>Better retention with air abrasion together with acid etching</td>
</tr>
<tr>
<td>Lepri et al (2008)(^4)</td>
<td>24</td>
<td>Er: YAG laser</td>
<td>Not better retention</td>
</tr>
<tr>
<td>Kanellis et al., (1997)(^4)</td>
<td>300</td>
<td>Air abrasion alone vs acid etching</td>
<td>Similar results for occlusal surfaces</td>
</tr>
<tr>
<td>Duangthip and Lussi (2003)(^5)</td>
<td>90</td>
<td>Air abrasion together with acid etching vs pumice prophylaxis</td>
<td>Not better results versus traditional pumice prophylaxis</td>
</tr>
<tr>
<td>Blackwood JA et al (2002)(^6)</td>
<td>60</td>
<td>Pumice prophylaxis vs enameloplasty, versus air abrasion</td>
<td>Same results between them (all followed by acid etching)</td>
</tr>
<tr>
<td>Ellis et al (1999)(^6)</td>
<td>84</td>
<td>Air abrasion</td>
<td>Better retention scores together with acid etching</td>
</tr>
<tr>
<td>Lupi-Pegurier et al (2004)(^5)</td>
<td>90</td>
<td>Sono-abrasion alone vs enameloplasty</td>
<td>Similar results</td>
</tr>
</tbody>
</table>

Air abrasion for the preparation of teeth for sealants is a fairly recent innovation. It has been suggested that it improves adhesion by eliminating steps of application of acid and rinsing\(^2\) and constitutes a less invasive procedure\(^1\). It has also been proposed for removing prismless enamel, superficial caries, and enlarging and cleaning fissures to achieve better retention\(^4\). In an investigation concerning preparing deciduous molars with air abrasion, a stronger bond was achieved with the combined use of air abrasion and acid etch than with acid etch alone\(^1\). The superiority of this combination over acid etch alone is consistent with other studies\(^41-43\), but air abrasion alone is thought to be inadequate\(^41, 44\). A recent paper concerning evidence-based

**Table 1. Cleaning methods and retention rate**

Reduced retention to an extent that surprised the authors\(^39\). Added to this, a study comparing conventional pumice preparation with enameloplasty and air-abrasion found no difference in micro-leakage scores\(^40\).
Isolation Type

Literature strongly supports that saliva contamination is detrimental to sealant retention. The moisture and the saliva encourage creation of an organic layer in contact with the etched surface and thereby jeopardize retention.

The best way of optimizing isolation is by using a rubber dam. In other words, even 1 second of contact with saliva can reduce bond strength by 50 to 100%. In a systematic review of the literature the authors concluded that with auto-polymerized resin based sealants, retention seems to be unaffected when cotton rolls are chosen. These conclusions are also supported by the European guidelines where, while the dam still remains the optimal means of isolation, the use of cotton rolls with the right amount of water and an evacuation tip, are thought to be an effective and easy way of achieving isolation.

The Irish guidelines arrive at the same conclusion. Researching the same issue, a double blind study by Lygidakis et al also found no differences between the type of isolation chosen. This is also confirmed by Straffon et al who, in a study about sealant efficacy, found that the retention rate was up to 95% when using cotton rolls and 94.3% for a rubber dam.

In a clinical study that tested the differences between the isolation obtained using cotton rolls and the Isolate system (IS - a plastic device placed in the cavity with an integral light source, tissue retraction and isolation ability covering half of the cavity), the latter showed reduced working time and, as a result, the authors hypothesized, better retention. Confirming this would require further and longer term examination. For others, better isolation can be obtained by correct patient positioning, the use of a mouth mirror when retracting tissues, and placing the evacuation tip over the roll to take off most of the moisture. However, the idea of using extra drying agents after the etching was not proved to be beneficial. When there is inadequate isolation, glass ionomer sealants can be an adequate temporary solution.

Etching

All failures involving adhesion, are due to non-optimal processes concerning cleaning and preparing the micro cavity of the fissure. The vast amounts of data from investigations, however, leave much room for discussion. Firstly, retention is related to completely acid conditioned enamel. The tags created are the mechanism of the bond that constitutes retention. The etchant is provided as a gel or liquid and the acids used are mainly orthophosphoric acid, maleic acid and nitric and citric acids. Examination of the literature indicates that both liquid and gel produce good results. Assisting flow by the use of a brush is suggested for both.

On the subject of etching time, most authors believe that 15 or 20 seconds are as effective as etching for 60 seconds although some found differences between 40 and 60 seconds, in favour of the latter. Furthermore, earlier results concerning optimal etching time for bond strength have shown no significantly different results from varied etching times. The authors found that for the thin gel, application for 60 seconds produced different results from 20 seconds. However, they questioned the clinical significance of this. Generally, they recommended application for 20 or 30 seconds.

Regarding etchant viscosity, the previous study did not find any advantage between the liquid, the thick and the thin forms of the etchant.

Rinsing and Drying

On the subject of the optimum time for rinsing the surface, there is a belief that less than 20 seconds is sufficient and that the vigour of washing and drying is more important for success than the time itself. However, others propose that rinsing for 30 seconds with water and air should be followed by 15 seconds drying. Another reported opinion is that, when a gel etchant is used, one should rinse for almost 90 seconds, as opposed to only 60 seconds with the liquid form. It should be noted that the presence of oil in the air-water syringe can compromise etching.

Application Technique

Another topic that is abundantly studied is the use of adhesive agents and their contribution to retention. Sufficient retention is obtained by thorough application.

Bonding Agent underneath the Sealant

There are interesting data regarding the concept of achieving better retention by the use of a bonding agent before placing the sealant. The general belief is that the use of an agent provides extra protection and retention in terms of moist conditions, better flow and more flexible combination of the primer adhesive and resin. In an early 2-year clinical evaluation between 2 sealant products placed with and without bonding agent, 1 sealant showed better rates with the bonding agent but only in the earliest stage of evaluation. The other sealant had the same retention results irrespective of the bonding agent; thus the authors did not support a stand point that retention is enhanced by a bonding agent. The same conclusions have been reported by other authors. Similarly, in a split-mouth study forming part of an oral school program, the authors were surprised to find that no differences were seen in retention, with or without a bonding agent. It should also be added that they used rubber dam for isolation.

However, a recent study demonstrated enhanced retention performance when using a bonding agent than with the acid technique alone. For similar protocols,
when micro-leakage was tested as a side-effect of marginal adaptation, the best results were obtained with the use of underlying bond agent68. Therefore, the authors felt that application of sealants together with a bonding agent, as an additional stage, seemed to be “their golden standard”68. In a 5-year clinical study by Feigal et al (1993), the single-bottle systems (fifth generation) enhanced retention in terms of reducing risk of loss by half, whereas previous generation agents showed no such success (no long term success)55. More success was achieved on buccal and lingual surfaces due to their ability to absorb forces on these more flexible areas. On the same subject, on salivary contaminated enamel, the use of adhesive systems provided the best sealing51, 53.

Concerning the same issue Feigal et al55 carried out a 2-year clinical study where sealants were successfully retained despite 10 seconds of contamination by using Scotchbond® as an underlying hydrophilic layer. They found equal retention with the conventional way of applying a sealant, thus suggesting a very good clinical solution for retention when there is insufficient moisture control.

Positive results were also produced by a study of children with MIH, where the use of a 2-step etch and rinse, single bottle adhesive (5th generation) enhanced sealant retention69. Authors attributed this to the ability to achieve deep penetration in the etched surface and good tag formation69.

Another interesting topic is bond layer thickness; failure has been attributed to very thin bond layers50. Concerning the same issue Feigal et al55 recommended a full 2, 3 second thinning of the layer with the air syringe in terms of evaporating the moisture and enhancing success. The acetone constituent of the adhesive can also enhance bond strength69. When examining the use of bonding agents in the context of an oil-contaminated surface due to the air-water-syringe, they found that the use of an acetone-based bonding agent enhanced adhesion, whereas an ethanol-based bonding agent produced no such effect53.

Self-Adhesive/Etching Agents

Regarding self adhesive agents, it was proposed that combination of avoiding the rinsing stage, and the ability to obtain better adhesion, made them as an interesting concept in terms of retention26,52,70. Thus, if they can effectively bond the sealant to the enamel, they will simplify the process for patients inconvenienced by standard etching-rinsing procedures. Consequently, studies examining the bond strength of these self adhesives are very important, in coming to conclusions about their retention ability71. This is thought to be a very interesting topic for achieving more ergonomic application of sealants and, therefore, is analyzed as far as possible in the present paper.

An in vitro study, testing the adhesion level of a sealant with a self-etching system, showed similar retention to sealants applied alone to uncontaminated enamel, and higher than sealants applied with the etch and rinse system; leading to the conclusion that single-bottle adhesives have the ability to penetrate deeply into micro-spaces51. In the same study, different curing procedures did not affect the result. Promising results for the future use of self etching agents were also obtained by a 2-year study of resin restorations, where clinical results showed longevity and good retention71.

More information about the capability of self adhesive agents is demonstrated in a study comparing phosphoric acid with the Adper Prompt L-Pop®72. It achieved similar results and higher retention when the agent was applied in 2 layers and separately cured; it also showed better performance than other adhesives. However, another 12-month school-based programme studied the same sealant and showed that the conventional procedure with phosphoric acid produced much better results than the self-etching primer adhesive73. Moreover, a RCT study undertaken for the UK National Health community dental service, which tested Xeno 3® as a self etching agent against traditional acid etching with the use of Prime & Bond®, found that the former had lower retention rates and reinforced the superiority of the latter, which is in line with most of the relevant literature74. Additionally, another in vitro study of the use of self-etching primer agents showed same results in comparison with conventional etch and rinse procedures, but performed better when a ceromer product was used as a sealant material, indicating that their use can be a good choice as alternatives to traditional etching with phosphoric acid74. In another retrospective study76 regarding the clinical rates of Dyract Seal, a sealant applied under no rinsing conditions with a rubber dam, the findings were lower with respect to reported results for conventional sealants, but the authors suggest it can be a good short-termed choice for deciduous teeth and when there is a pronounced gag reflex.

Additionally, the self adhesive (Adper Premt-L-Pop) has produced comparable results to conventional bonding systems in a study of 3 different procedures about bond values with respect to authors’ reference for more confirmation data67. However, the same self adhesive, when used with 2 different polymerization regimes, failed to produce good retention in recently erupted molars77. In a similar study67, the self adhesive achieved comparable results to the use of a bonding agent prior to the sealant, in contrast to other studies that authors refer to in their paper. When the same self etching agent was compared with acid etching, it failed to produce better results62. This agrees with another recent study of a new self etch sealant for which there were, at that time, no supporting data. It produced a lower level of bonding than conventional sealants. More research is needed in an in vivo environment to assess its likely clinical performance71.
The recent literature reflects consensus that traditional etch and rinse techniques still remain procedure of choice. In the evidence-based recommendations of Beauchamp et al\textsuperscript{23}, the self-etching bond agents are not recommended as replacements for traditional etching due to their low retention scores. This is consistent with another recent evidence-based article which did not find sufficient data to support their use and concluded they should not be recommended\textsuperscript{25}. Yazici et al\textsuperscript{78} also reported, from their clinical testing, the superiority of the traditional etch-and-rinse method. Their histological explanation for the failure of the self adhesive was that it could not provide as effective an etched pattern as the phosphoric acid when applied separately and rinsed. Similar explanations for the failure of self-adhesives by observing their histological pattern appears in another study concerning the differences in penetration achieved by the two methods in question\textsuperscript{79}.

When considering how the properties of self-etching systems could be improved, it is notable that their adhesion to mechanically prepared enamel is better than to non-prepared surfaces, with the exception of one total-etch adhesive, which showed strong bonding no matter the preparation procedure\textsuperscript{80} (Table 2).

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<table>
<thead>
<tr>
<th>Study</th>
<th>Number of teeth</th>
<th>Product(s)</th>
<th>Overall outcome of success of self adhesive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celiberti and Lussi (2005)\textsuperscript{63}</td>
<td>80</td>
<td>Xeno 3\textsuperscript{b}</td>
<td>No significant difference in retention rate</td>
</tr>
<tr>
<td>D. Gillet et al (2002)\textsuperscript{75}</td>
<td>24</td>
<td>Prompt\textsuperscript{b}</td>
<td>No significant difference in retention rate</td>
</tr>
<tr>
<td>Dos Santos KT et al (2008)\textsuperscript{79}</td>
<td>36</td>
<td>Adper Prompt L-Pop\textsuperscript{b}</td>
<td>No significant difference in retention rate</td>
</tr>
<tr>
<td>Venker DJ et al. (2004)\textsuperscript{71}</td>
<td>208 students of a school-based sealant program</td>
<td>Prompt-L-POp\textsuperscript{b}</td>
<td>No significant difference in retention rate</td>
</tr>
<tr>
<td>M.E Asselin et al (2008)\textsuperscript{68}</td>
<td>63</td>
<td>Adper Prompt L-Pop\textsuperscript{b}</td>
<td>No significant difference in retention rate</td>
</tr>
<tr>
<td>J. M. Gomes-Silva et al (2008)\textsuperscript{52}</td>
<td>45 with saliva contamination</td>
<td>Clearfil S3 Bond\textsuperscript{b}</td>
<td>No significant difference in retention rate</td>
</tr>
<tr>
<td>AR Yazici et al (2009)\textsuperscript{78}</td>
<td>244</td>
<td>FuturaBond NR\textsuperscript{b}</td>
<td>No significant difference in retention rate</td>
</tr>
<tr>
<td>L. Burbridge et al., (2006)\textsuperscript{74}</td>
<td>162</td>
<td>Xeno 3\textsuperscript{b}</td>
<td>No significant difference in retention rate</td>
</tr>
</tbody>
</table>

**Filling Level of the Fissure**

There is some evidence about the effect of the filling level of the fissure. Geiger et al. demonstrated in an *in vitro* study, that overfilled fissures seem to suffer greater sealant loss than those that are border filled\textsuperscript{31}. This can be explained by the existence of parts of the material exposed to higher levels of light and therefore undergoing greater shrinkage\textsuperscript{30,31,33}. The general consensus seems to be that all pits and fissures should be covered to obtain good retention and that the thickness of the material is of less importance\textsuperscript{81}. The existence of bubbles within the sealant was not generally detrimental, except when they occurred in the margins. This leads to recommendations that, when polymerizing a sealant with load particles, it should be applied under vibration\textsuperscript{59,60}. There are also suggestions that better penetration occurs when material is left to flow for 20 seconds before curing than when it is left for a shorter time\textsuperscript{22} or left as long as possible\textsuperscript{15}.

The use of an air polishing device helped investigators to achieve good retention in an early study\textsuperscript{59}. However, others found that the device does not allow material to flow deeply enough due to the trapped air\textsuperscript{35}.

In the end, the meticulous examination of sealant margins after placement with the use of a probe to reveal indications of early retention failure remains of crucial importance\textsuperscript{22,82}.

**Conclusion**

The retention ability of a sealant is crucial because most failures are of an adhesive nature. Thus, when retention is jeopardized, the overall anti-caries effectiveness of the sealants is in question, too\textsuperscript{12}.

When it comes to the factors as examined in the current study, some have been analyzed in greater depth than others, and for some there is a greater degree of consensus in the literature. The data given for the type and position of the tooth is not so clear, and sealant retention on primary molars is still a field that requires more investigation\textsuperscript{4}. One of the factors most analyzed regarding clinical impact is preparation of the surface before application of the sealant. In the literature, fissurotomy seems to enhance retention, but is not recommended as a routine preparation due to its invasive nature. More supporting data is needed about the use of air abrasion and lasers since that extant is unsatisfactory. It is interesting to
note that some references are to sealants as part of microtherapeutic invasive technique, rather than as a solely preventive procedure.

Numerous studies confirm the use of cotton rolls as free of risk to the isolation required. However, the most important factor for isolation and therefore ensuring retention and longevity is the state of eruption, where the literature suggests having as full an eruption status as possible. Regarding the idea of applying a bonding agent under the sealant, the facts are positive overall. However, concerning the recently discussed use of self-adhesives because of their ergonomic characteristics, the results are still inconclusive and more clinical trials are needed. More data is also required about sealant viscosity and the type of material and sealant retention.

The main idea pervading the available literature is that the central issue is no longer the effectiveness of sealants, but how the factors discussed above contribute to the desired clinical outcomes of every day sealants practice.

References

Exploring four-handed delivery and retention of resin-based sealants for the prevention and management of pit and fissure prophylaxis on retention of sealants.


Evaluation of pumice, fissure enameloplasty and air abrasion on shear bond strength of a fissure sealant placed with and without air abrasion pretreatment in clinically placed fissures.


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