In vitro study of penetration of flowable resin composite and compomer into occlusal fissures

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ABSTRACT. The penetration of a sealant into the tooth fissures can establish longer retention time for a pit and fissure sealant restoration. Aim This in vitro study was to evaluate the penetration ability of two low-viscosity resin materials, a composite and a compomer, applied with and without their bonding agents in comparison to an unfilled resin sealant. Methods Forty premolars with shallow/wide (group I) and forty with deep/narrow occlusal fissures (group II) were used. Each group was divided into five subgroups (A-E). The teeth in the subgroups were sealed as follows: A - Delton LC Clear (unfilled resin); B - Dyract flow (compomer); C - Prime&Bond NT (bonding agent) and Dyract flow; D - Tetric flow (resin composite); E - Syntac Sprint (bonding agent) and Tetric flow. Longitudinal sections were cut along the mesiodistal direction of fissures and examined under a videomicroscope. The resin penetration was rated according to the scale “low”, “medium”, “high”, indicating penetration up to one third and two thirds of fissure depth and to the fissure bottom, respectively. Results These revealed the following: a) the penetration of all sealants was higher in shallow/wide than in deep/narrow fissures; b) the low-viscosity resin materials provided higher penetration than the unfilled resin sealant in shallow/wide fissures, whereas the unfilled resin achieved superior penetration rates in deep/narrow ones; c) the combination of a hydrophilic sealant (Dyract flow) with a hydrophilic bonding agent (Prime&Bond NT) significantly promoted the penetration depth in deep/narrow fissures. Conclusion The penetration ability of all sealants was higher in shallow/wide than in narrow/deep fissures; low-viscosity resin composite and compomer provided higher penetration efficiency than the unfilled resin sealant in shallow/wide fissures, whereas the unfilled resin achieved superior penetration rate in deep/narrow ones. The combination of a hydrophilic sealant with a hydrophilic bonding agent significantly enhanced the penetration depth in deep/narrow fissures.

KEYWORDS: Fissure, Penetration, Low-viscosity, Compomer, Sealants

Introduction

Pit and fissure sealants have been recognized as an effective means of preventive treatment for pit and fissure caries [Manton and Messer, 1995]. However, the prognosis of the sealing materials, especially their longevity under clinical conditions, is questionable. Jensen et al. [1985] reported 50% of sealant volume loss after one month oral service. Furthermore, a reduction in maximum sealant depth due to wear has been found, ranging from 89 to 148 µm after 6 months clinical life [Leinfelder et al., 1986; Conry et al., 1990; Pintado et al., 1991]. Although the clinical effectiveness of the partially retained sealants in caries prevention is still a matter of debate, cariostatic effect has been reported [Hinding, 1974; Simonsen, 1991].

It can be assumed that the ability of a sealant to adequately penetrate and fill a fissure can ensure longer retention time, even when the uppermost occlusal part of the sealant has been removed due to occlusal wear. The clinical problems described above are mostly associated with unfilled and low filler-loaded resin sealants [Shapira et al., 1990; Bravo et al., 1997; Grande et al., 2000], which demonstrate poor mechanical properties [Braem et al., 1989; Park et al., 1990].

Sealant materials with improved physicomechanical properties are expected to provide superior clinical performance. Thus, low-viscosity resin composites, loaded with 40% to 53% weight of inorganic filler...
The products tested were:
- an unfilled resin sealant (Delton LC Clear, Dentsply/DeTrey, Germany);
- a low-viscosity compomer (Dyract flow, Dentsply/DeTrey, Germany);
- a low-viscosity resin composite (Tetric flow, Vivadent, Liechtenstein).

Prior to sealant application, each occlusal fissure received a prophylaxis with a pumice slurry and was then cleaned with a sharp probe. The occlusal fissures were acid etched for 30s with a phosphoric acid gel (36 DeTrey Conditioner, Dentsply/DeTrey, Germany), water rinsed for 15s and air dried for 20s. The specimens of each group were divided into five subgroups (A-E) of eight teeth each.

The teeth in each subgroup were sealed as follows: in subgroup A with Delton LC Clear; in subgroup B with Dyract flow; in subgroup C with the bonding agent Prime&Bond NT (Dentsply/DeTrey, Germany) and Dyract flow; in subgroup D with Tetric flow; in subgroup E with the bonding agent Syntac Sprint (Vivadent, Liechtenstein) and Tetric flow. The manufacturers' recommendations were followed for the application of the two bonding agents. In subgroup C, the enamel was etched for 30s, rinsed off for 10s, gently air dried for 3-4s, then the Prime&Bond NT adhesive was placed, it remained on the surface for 25s, it was air dried for 5s and photopolymerized for 15s. In subgroup E, after enamel etching for 15s, rinsing off for 10s, gently air drying for 3-4s, Syntac Sprint was applied, air-dried for 10s and light cured when placed the Tetric flow.

All materials were photopolymerized for 40s with a light curing unit (Demetron, emitting 650 mW/cm² light intensity as measured by a curing radiometer Demetron Model 100, Demetron Research, USA). Photopolymerization was performed 20s after resin placement to improve sealant penetration.

Following 24h water storage (37±10 C) under dark conditions, longitudinal sections were cut through the central fissure of each tooth in a mesiodistal direction using a hard tissue microtome (Macrotome 2, Metals Research, Cambridge, England) equipped with a diamond disk. All sections were examined under videomicroscope (MS-500C micro-Scopeman, Moritex, Cambridge, England) using a 20x objective lens.

Resin penetration depths were recorded for each section and rated according to the following scale: a) “low”, resin extending to one third of fissure depth; b) “medium”, resin extending to two thirds of fissure depth; c) “high”, resin extending to the fissure base.

Differences among the subgroups were defined by statistical analysis with Kruskal Wallis test, at a=0.05 significance level.

Results
The penetration scores of all materials in shallow/wide and deep/narrow fissures are depicted in Figures 2 and 3, respectively. The penetration
depth of the products tested in all subgroups was significantly higher in the group of shallow/wide fissures compared to the group of deep/narrow fissures.

All the teeth with shallow/wide fissures sealed with Dyract flow exhibited “high” penetration. A significantly lower number of teeth (p<0.05) sealed with Tetric flow (87.5%) and Delton (62.5%) demonstrated the same rate. The application of the respective bonding agent in combination with Dyract flow and Tetric flow did not influence the number of “high” ranked penetration fissures.

None of the materials evaluated provided “high” resin penetration in teeth with deep/narrow fissures. The highest number of teeth with “medium” sealant penetration was found in Delton LC Clear (50%). A significantly lower number of teeth (p<0.05) sealed with Dyract flow (37.5%) and Tetric flow (25%) demonstrated “medium” penetration when the corresponding bonding agents were not applied. The application of Prime&Bond NT enhanced Dyract flow penetration whereas Syntac Sprint significantly decreased the penetration of Tetric flow.

The microscopic examination revealed that 65% of the teeth with deep/narrow fissures presented plaque and/or caries at the fissure bottom (Fig. 4), whereas all shallow/wide fissures appeared clean. Thick layers of the bonding agents were found at the bottom of shallow/wide fissures in six out of sixteen teeth (Fig. 5). The same finding was not established for the subgroups with deep/narrow fissures.

**Discussion**

Even though the sealing efficiency of pit and fissures and the penetration into the etched enamel is
of prime importance in caries prevention [Wright and Retief, 1984; Barnes et al., 2000; Irinoda et al., 2001], it is postulated that the in-depth sealant penetration into the pit and fissures applied can further prolong sealant retention and longevity. Thus, various materials and techniques for sealant penetration improvement have been studied [Percinoto et al., 1995; Bottenberg et al., 1996; Symons et al., 1996; Geiger et al., 2000; Kersten et al., 2001].

It is obvious that the complex morphology of occlusal pits and fissures reduces the extent of sealant penetration. It can be assumed that the penetration of a sealant into a fissure is determined by the groove diameter, the surface energy and the sealant density and viscosity [Barnes et al., 2000]. Time is also of importance. The procuring time lapse of 20s was followed in the present study because prolonged contact time was reported to be important for adequate enamel bonding and sealant penetration of visible light cured materials [ten Cate et al., 1975; Waggoner and Siegal, 1996].

Cleaning and conditioning of the fissures can remarkably influence the penetration behaviour of the sealants. Although a variety of pretreatments have been suggested prior to sealant application, all appear to demonstrate equal clinical efficiency [Manton and Messer, 1995; Waggoner and Siegal, 1996; Gillerist et al., 1998]. It has been shown that debris and pellicle cannot be removed from fissure bottom neither after routine cleaning by pumice [Burrow and Makinson, 1990] nor by acid etching, due to implication of various factors such as air entrapment and wettability of the etching agent [Futatsuki et al., 1995].

The prevalence of caries and sealant remnants detected in the present study at the bottom of the deep/narrow fissures is in agreement with the results of previous studies [Burrow and Makinson, 1990; Feldens et al., 1994]. A primary disadvantage of these remnants was that incomplete fissure penetration was achieved because no infiltration was obtained by the sealants.

Although an aqueous non-rinsing conditioner of alkeonic and maleic acid is advised for enamel conditioning prior to Dyract flow application in the present study, for compliance with other treatments, phosphoric acid conditioning was used, proposed as an optional treatment for Dyract flow [Technical manual, 1998]. In addition, as a bonding agent is not recommended to be used with the resin sealant Delton LC Clear, a corresponding subgroup was not established.

Some shallow/wide fissures seem to facilitate retention of bonding agents, which form a thick layer at the fissure bottom and then penetration of Dyract flow and Tetric flow fails to exceed to the fissure bottom. A control factor in penetration into deep/narrow fissures when the sealants were applied directly to the etched enamel surface was the flow capacity of the materials. Thus, the unfilled free-flowing Delton LC Clear resin penetrated to a greater depth in a higher number of teeth compared with the more viscous Dyract flow and Tetric flow materials. Such a finding was not noticed in shallow/wide fissures.

The results of the current study showed that narrow/deep fissures of the premolars used eliminated the sealant penetration independent of the material type. It can be assumed that the application of the same sealants on occlusal surfaces of molars, which contain more precipitous fissures, should result in a further decrease of sealant penetration.

Dyract flow showed the highest penetration of all materials into shallow/wide fissures and better performance than Tetric flow in deep/narrow fissures when no bonding agents were used. It is well established that phosphate carboxyl modified monomers contained in Dyract flow [Technical manual, 1998] provide a hydrophilic nature to the material, which promotes the monomer diffusion [Wang et al., 1991]. Therefore, when Dyract flow is placed directly on an acid etched surface, it can easily penetrate into the high surface tension enamel substrate [Gwinnet, 1988]. Contrary to that, the hydrophobic nature of Tetric flow may limit the in-depth penetration into the hydrophilic substrate.

Both the adhesives used are hydrophilic and may better penetrate into the hydrophilic etched tooth structure [Gallo et al., 2000; Manhart et al., 2001]. However, while Prime&Bond NT enhanced the penetration of Dyract flow, Syntac Sprint considerably reduced Tetric flow penetration. This may be explained by either the differences in film thickness and viscosity, that may result in a thicker adhesive zone in Syntac Sprint or by the relative hydrophilic structure of Dyract flow, that is more compatible to the primed enamel walls than the hydrophobic Tetric flow.

**Conclusion**

The penetration ability of all sealants was higher in shallow/wide than in narrow/deep fissures. The low-viscosity resin composite and compomer provided higher penetration efficiency than the unfilled resin sealant in shallow/wide fissures, whereas the unfilled
resin achieved superior penetration rate in deep/narrow ones. The combination of a hydrophilic sealant with a hydrophilic bonding agent significantly enhanced the penetration depth in deep/narrow fissures.

References


