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# Surface Roughness of Pit and Fissure Sealants After Immersion in Different Beverages

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### Abstract

***Background:*** The purpose of this study was to investigate surface roughness of pit and fissure sealant before and after their exposure to different beverages.

***Methods:*** Three pit and fissure sealants (Clinpro, UltraSeal XT hydro, Fissurit FX) were used in this study. Eighty-four specimens (8 mm diameter and 2 mm height) of 3 pit and fissure sealants were immersed in soft drink, pasteurized milk, orange juice, and artificial saliva for 2 minutes daily and following a distilled water rinse, the specimens were immersed in fresh distilled water at 37°C for 24 hours. Surface roughness was measured using a contact profilometer 3 different times: baseline, 15 days, 30 days. Data were analyzed statistically using Kruskal–Wallis test and Friedman test.

***Results:*** There was no statistically significant difference in Fissurit FX, Clinpro, and UltraSeal XT hydro between different beverage groups in terms of surface roughness at T0, T1, and T2 times ($P > .05$). No statistically significant difference was found between the fissure sealant groups in terms of surface roughness at baseline, 15 days, and 30 days when immersed in different beverages groups ($P > .05$).

***Conclusion:*** Acidic beverages did not result in a statistically significant difference in the surface roughness of Clinpro, Fissurit FX, and UltraSeal XT hydro. However, it has been determined that the surface roughness of UltraSeal XT hydro is mathematically less.

***Keywords:*** pit and fissure sealant, surface roughness, acidic beverages

## INTRODUCTION

The term "pit and fissure sealant" refers to a material that is applied to the occlusal pits and fissures of teeth that are prone to dental caries, thereby creating a physical barrier that is micromechanically linked, preventing the caries-causing bacteria from accessing the nutrition source.[1] By creating a protective layer in those deep zones, sealing the pits and fissures of primary and permanent teeth has been thought to be an efficient way to prevent and arrest caries.[2] Sealants have been first introduced to stop caries on occlusal surfaces, but now as their uses have expanded, they are also thought to be active agents in the treatment and control of early carious lesions on both occlusal and approximal surfaces.[3] According to the American Academy of Pediatric Dentistry, this procedure can be a component of a complete strategy for controlling dental caries.[4]

The acid-etch procedure was first presented by Buonocore in 1955, which really marked the start of a revolution in dental clinical practice and a decade later, Cueto and Buonocore developed fissure sealants.[5] There are a wide variety of sealants on the market, ranging from partially filled to unfilled, opaque, transparent, white, or other colors, chemically polymerized, or visible light-cure started materials, and fluoride-containing or not.[1,5]

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For fissure sealants to be properly used as preventive agents, they must stay on the fissure surface for many years. Regarding this, fissure sealant's physical characteristics, such as its surface texture, have been crucial to its longevity.[6] One of the factors contributing to the long-term success of fissure sealants is a smooth surface.[7] High surface roughness of the fissure sealants causes increased plaque accumulation, resulting in the development of dental caries and periodontal inflammation.[8] Nonetheless, since dental materials are at risk from physical pressures, temperature, and pH changes similar to teeth, some of their qualities are also impacted by the oral environment. These changes, which arise from a variety of factors, including the consumption of food and beverages, modify the surface of the material and may eventually have no bearing on its success as a treatment.[9,10] Children's consumption of industrialized fruit juice, soft drinks, and energy drinks has increased recently due to changes in lifestyle. The acidic pH and cariogenic sugar in the structure of these drinks affect both teeth and dental materials.[11,12] For this reason, knowing the effect of different beverages on the surface roughness of fissure sealants is important in terms of allowing the selection of the appropriate fissure sealant in clinical applications. There are very few studies on this subject in the literature. Therefore, the aim of this study was to investigate the surface roughness of pit and fissure sealant before and after their exposure to different beverages.

## MATERIAL AND METHODS

Three types of commercial pit and fissure sealants were used in this study; Clinpro (3M ESPE, Saint Paul, Minn, USA), UltraSeal XT hydro (Ultradent Products, South Jordan, Utah, USA), Fissurit FX (VOCO GmbH, Cuxhaven, Germany). Table 1 shows the composition and manufacturer of each tested material.

### Specimen Preparation

Pit and fissure sealant specimens were prepared using a Teflon mold (8 mm diameter and 2 mm height) following the manufacturer's instructions by single operator. Each tested material was added to the mold without overflowing it, and the excess was extruded by lightly pressing on a glass slide coated in the mold. Then, each tested sealant was polymerized from the top surface with an LED curing unit (Valo Standart Power, Ultradent) according to the manufacturer's instructions. The specimens were polished using a Sof-Lex polishing system (3M ESPE, St. Paul, Minn, USA) under water coolant for 10 seconds (the duration of each disk), applying from coarse to fine. In order to complete the polymerization, all specimens were stored in distilled water at 37°C for 24 hours.

### Sample Size

Sample size calculation was performed using the G*Power 3.1.9.7 (Universitat Kiel, Germany) program. Partial eta-squared ($\eta^2$) effect size measure was used. When the power of the study is determined as 80%, $\alpha$: 0.05, and $\eta^2$: 0.06, representing a moderate effect, it was determined that the sample size should be at least 84. Thus, in the study that included 12 subgroups, 7 specimen discs were included for each subgroup.

### Experimental Groups

A total of 84 specimen discs were used. For every commercial brand of pit and fissure sealant, a group of 28 discs was provided. The groups were subsequently divided into four subgroups (n=7) based on the various beverages for immersion (soft drinks, pasteurized milk, orange juice) and control group.

### Immersion of Different Beverages

Three immersion solutions used were; Coca-Cola (Coca-Cola, Atlanta, Ga, USA), Cappy orange juice (Coca-Cola, Atlanta, Ga, USA), Pınar milk (Yaşar Comp., İzmir, Turkey), and artificial saliva as the control group (distilled water, 1 mM $CaCl_2$, 50 mM KCl, 2 mM $KH_2PO_4$, and 0.01% $NaN_3$, pH adjusted to 7 with 1M KOH).[13]

The specimens were submerged in a 5 mL immersion solution at room temperature (23 ± 1°C) for a duration of 2 minutes and following a distilled water rinse, the specimens were immersed in fresh distilled water at 37°C for 24 hours.[14] For 2 immersion periods of 15 days and 30 days, this cycle—2 minutes in the immersion solution, a rinse in distilled water, and a 24-hour period in distilled water—was repeated every day.[14] Control specimens were immersed in 5 mL of artificial saliva, and changed daily. Experiment design are shown in Figure 1.

### Surface Roughness Measurement

Using a contact profilometer (Surtronic S-128, Taylor Hobson, Leicester, England, UK), the surface roughness of

Table 1. Composition and Manufacturer of Pit and Fissure Sealants

| Materials | Composition | Manufacturer |
|---|---|---|
| Clinpro | Bis-gMa, TegdMa, silane, tetrabutilamonyum tetrafloaborat, diphenyl hexafluorophosphate, edMaB, titanium hydroxide, hydroquinone | 3M Espe, Minn, USA |
| UltraSeal XT hydro | Triethylene glycol dimethacrylate, diurethane dimethacrylate, aluminum oxide, methacrylic acid, titanium dioxide, sodium monofluorophosphate | Ultradent Products, South Jordan, Utah, USA |
| Fissurit FX | Bis-GMA, TEGDMA, UDMA, BHT, benzotriazole derivatives, inorganic glass ionomer filler, NaF (NA) | VOCO GmbH, Cuxhaven, Germany |

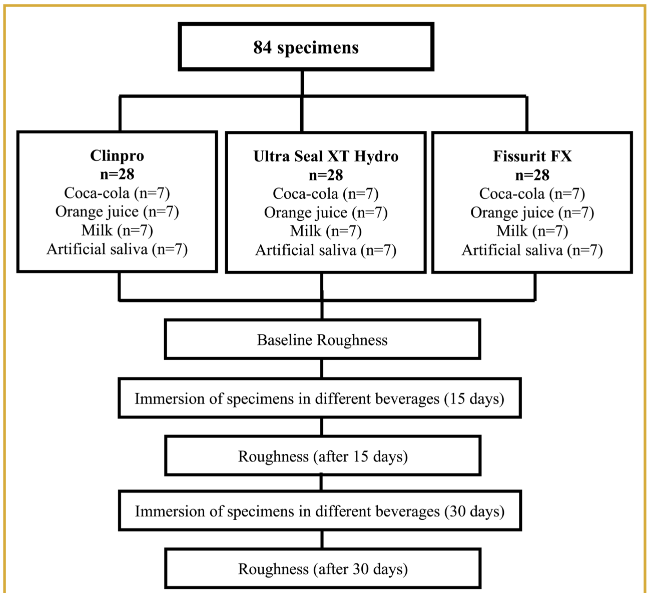


**Figure 1. XFlow of the Experiment Design.**

every sample was measured 3 different times: first at baseline along with after 15 and 30 days of immersion in beverages.

The surface roughness measurement (Ra) was performed by the same operator (M.K.Ü), perpendicular to the disc surface, with a tracking length of 1.5 mm and a cutoff value of 0.25 mm. Ra is the roughness irregularities' arithmetic average height of roughness irregularities, as determined from a mean line in the sampling length. The mean value was calculated by evaluating 3 different regions of each sample. The profilometer was calibrated before each new measurement.

### Statistical Analysis

Statistical analysis was performed with The Statistical Package for Social Sciences version 22.0 software (IBM Corp.; Armonk, NY, USA). The suitability of the normal distribution parameters was assessed for the data using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Kruskal–Wallis test for inter-group comparisons of parameters; Friedman test was used for intra-group comparisons. Significance was evaluated at $P < .05$ level.

## RESULTS

The pit and fissure sealants' surface roughness values in different beverages are presented in Table 2. There was no statistically significant difference in Fissurit FX, Clinpro, and UltraSeal XT hydro between different beverage groups in terms of surface roughness at T0, T1, and T2 times ($P > .05$). No statistically significant difference was found between the fissure sealant groups in terms of surface roughness at T0, T1, and T2 when immersion in different beverage groups ($P > .05$) (Table 3). Although all groups showed increases in surface roughness throughout the experiment, it was not statistically significant (Table 4).

## DISCUSSION

Dental materials placed in the oral environment are subject to numerous unfavorable factors that endanger their integrity and endurance over time, even with the noticeable improvement in their composition and properties.[15] Numerous factors, including temperature changes, acidic beverages consumption, and ionic composition of saliva in the oral cavity, are crucial conditions that may affect the physical properties of dental materials.[16] Consuming many kinds of beverages containing various acidic components, which are frequently

**Table 2. Evaluation of Surface Roughness According to Different Beverages in Fissure Sealant Groups**

| Fissure Sealants | Beverages | T0 Mean ± SD (Median) | T1 Mean ± SD (Median) | T2 Mean ± SD (Median) |
|---|---|---|---|---|
| Fissurit FX | Coca-Cola | 0.30 ± 0.18 (0.23) | 0.44 ± 0.37 (0.23) | 0.47 ± 0.55 (0.27) |
| | Orange juice | 0.31 ± 0.14 (0.30) | 0.33 ± 0.13 (0.37) | 0.35 ± 0.11 (0.40) |
| | Milk | 0.32 ± 0.18 (0.23) | 0.40 ± 0.23 (0.33) | 0.52 ± 0.19 (0.50) |
| | Artificial saliva | 0.32 ± 0.16 (0.27) | 0.44 ± 0.33 (0.27) | 0.44 ± 0.23 (0.37) |
| | *P* | .915 | .997 | .143 |
| Clinpro | Coca-Cola | 0.30 ± 0.19 (0.20) | 0.33 ± 0.11 (0.30) | 0.36 ± 0.18 (0.37) |
| | Orange juice | 0.29 ± 0.08 (0.33) | 0.31 ± 0.15 (0.27) | 0.33 ± 0.11 (0.33) |
| | Milk | 0.30 ± 0.10 (0.27) | 0.34 ± 0.15 (0.33) | 0.37 ± 0.36 (0.20) |
| | Artificial saliva | 0.28 ± 0.20 (0.20) | 0.33 ± 0.17 (0.27) | 0.34 ± 0.19 (0.27) |
| | *P* | .366 | .958 | .750 |
| UltraSeal XT hydro | Coca-Cola | 0.24 ± 0.05 (0.27) | 0.28 ± 0.11 (0.20) | 0.31 ± 0.14 (0.23) |
| | Orange juice | 0.25 ± 0.09 (0.20) | 0.29 ± 0.11 (0.20) | 0.32 ± 0.13 (0.27) |
| | Milk | 0.25 ± 0.14 (0.23) | 0.35 ± 0.12 (0.30) | 0.35 ± 0.13 (0.33) |
| | Artificial saliva | 0.24 ± 0.09 (0.20) | 0.26 ± 0.11 (0.20) | 0.28 ± 0.11 (0.20) |
| | *P* | .967 | .277 | .692 |

Kruskal–Wallis test, T0: baseline, T1: 15th day, T2: 30th day.

**Table 3. Evaluation of Surface Roughness According to Different Fissure Sealants in Beverage Groups**

| Beverages | Fissure Sealants | T0 Mean ± SD (Median) | T1 Mean ± SD (Median) | T2 Mean ± SD (Median) |
|---|---|---|---|---|
| Coca Cola | Fissurit FX | 0.30 ± 0.18 (0.23) | 0.44 ± 0.37 (0.23) | 0.47 ± 0.55 (0.27) |
| | Clinpro | 0.30 ± 0.19 (0.20) | 0.33 ± 0.11 (0.30) | 0.36 ± 0.18 (0.37) |
| | UltraSeal XT hydro | 0.24 ± 0.05 (0.27) | 0.28 ± 0.11 (0.20) | 0.31 ± 0.14 (0.23) |
| | *P* | .737 | .725 | .917 |
| Orange juice | Fissurit FX | 0.31 ± 0.14 (0.30) | 0.33 ± 0.13 (0.37) | 0.35 ± 0.11 (0.40) |
| | Clinpro | 0.29 ± 0.08 (0.33) | 0.31 ± 0.15 (0.27) | 0.33 ± 0.11 (0.33) |
| | UltraSeal XT hydro | 0.25 ± 0.09 (0.20) | 0.29 ± 0.11 (0.20) | 0.32 ± 0.13 (0.27) |
| | *P* | .493 | .951 | .771 |
| Milk | Fissurit FX | 0.32 ± 0.18 (0.23) | 0.40 ± 0.23 (0.33) | 0.52 ± 0.19 (0.50) |
| | Clinpro | 0.30 ± 0,10 (0.27) | 0.34 ± 0.15 (0.33) | 0.37 ± 0.36 (0.20) |
| | UltraSeal XT hydro | 0.25 ± 0.14 (0.23) | 0.35 ± 0.12 (0.30) | 0.35 ± 0.13 (0.33) |
| | *P* | .543 | .908 | .056 |
| Artificial saliva | Fissurit FX | 0.32 ± 0.16 (0.27) | 0.44 ± 0.33 (0.27) | 0.44 ± 0.23 (0.37) |
| | Clinpro | 0.28 ± 0.20 (0.20) | 0.33 ± 0.17 (0.27) | 0.34 ± 0.19 (0.27) |
| | UltraSeal XT hydro | 0.24 ± 0.09 (0.20) | 0.26 ± 0.11 (0.20) | 0.28 ± 0.11 (0.20) |
| | p | .452 | .513 | .278 |

Kruskal–Wallis test, T0: baseline, T1: 15th day, T2: 30th day.

preferred by children, may cause biodegradation in dental restorations.[17] According to a previous study, fissure sealants often deteriorate due to mechanical pressures and the presence of acidic substances (such as lactic acid, citric acid, and other acid beverages).[18] Additionally, the effect of a beverage on the properties of dental materials may be directly related to the amount and frequency of consumption.[15]

This study was carried out to evaluate the surface roughness of pit and fissure sealants following their varying periods of immersion in three commonly consumed beverages: a soft drink, orange juice, and pasteurized milk. The pH values of the liquids used in our study are as follows: Coca-Cola (pH 2.59), orange juice (pH 3.5), pasteurized milk (pH 6.5), and artificial saliva (pH 7). According to a previous studies, the softening of the resin matrix caused by acid solutions (pH 2.67-3.79) causes filler particles (unstable glass particles) to dislocate and elute, increasing the surface roughness of resin based materials.[15,19] Similarly, in our study, it was shown that the surface roughness of fissure sealants increased when exposed to acidic beverages, although there was no statistically significant difference. Baca-Solano et al.[10] reported that surface roughness increased in their study in which they exposed fissure sealants to three different acidic beverages [Coca-Cola (pH 2.59), apple juice (pH 3.3), and Yakult milk (pH 3.7)]. Previous studies have indicated that pasteurized milk and artificial saliva are the liquids that affect the surface roughness values the least in consistent with our study, and this is due to their high pH value of these liquids.[20] According to Karda et al.,[12] the lactic acid produced by the lactobacilli contained

**Table 4. Evaluation of Change Dependent on Time for All Groups**

| Surface Roughness | T0 Mean ± SD (Median) | T1 Mean ± SD (Median) | T2 Mean ± SD (Median) | *P* |
|---|---|---|---|---|
| F-C | 0.30 ± 0.18 (0.23) | 0.44 ± 0.37 (0.23) | 0.47 ± 0.55 (0.27) | .891 |
| F-O | 0.31 ± 0.14 (0.30) | 0.33 ± 0.13 (0.37) | 0.35 ± 0.11 (0.40) | .895 |
| F-M | 0.32 ± 0.18 (0.23) | 0.40 ± 0.23 (0.33) | 0.52 ± 0.19 (0.50) | .368 |
| F-AS | 0.32 ± 0.16 (0.27) | 0.44 ± 0.33 (0.27) | 0.44 ± 0.23 (0.37) | .717 |
| C-C | 0.30 ± 0.19 (0.20) | 0.33 ± 0.11 (0.30) | 0.36 ± 0.18 (0.37) | .687 |
| C-O | 0.29 ± 0.08 (0.33) | 0.31 ± 0.15 (0.27) | 0.33 ± 0.11 (0.33) | .867 |
| C-M | 0.30 ± 0.10 (0.27) | 0.34 ± 0.15 (0.33) | 0.37 ± 0.36 (0.20) | .163 |
| C-AS | 0.28 ± 0.20 (0.20) | 0.33 ± 0.17 (0.27) | 0.34 ± 0.19 (0.27) | .432 |
| US-C | 0.24 ± 0.05 (0.27) | 0.28 ± 0.11 (0.20) | 0.31 ± 0.14 (0.23) | .630 |
| US-O | 0.25 ± 0.09 (0.20) | 0.29 ± 0.11 (0.20) | 0.32 ± 0.13 (0.27) | .,161 |
| US-M | 0.25 ± 0.14 (0.23) | 0.35 ± 0.12 (0.30) | 0.35 ± 0.13 (0.33) | .368 |
| US-AS | 0.24 ± 0.09 (0.20) | 0.26 ± 0.11 (0.20) | 0.28 ± 0.11 (0.20) | .627 |

Friedman test, T0: baseline, T1: 15th day, T2: 30th day
F-C, Fissurit FX–Coca-Cola; F-O, Fissurit FX–orange juice; F-M, Fissurit FX–milk; F-AS, Fissurit FX–artificial saliva.
C-C, Clinpro–Coca-Cola; C-O, Clinpro–orange juice; C-M, Clinpro–milk; C-AS, Clinpro–artificial saliva.
US-C, UltraSeal–Coca-Cola; US-O, UltraSeal–orange juice; US-M, UltraSeal–milk; US-AS, UltraSeal–artificial saliva.

in Yakult beverage (pH 3.76) might cause fermented milk to contribute to the dissolving of the materials' structure, resulting in higher roughness owing to structural loss.[12] However, in our study, pasteurized milk did not have a statistically significant effect on the surface roughness of fissure sealants. This may be due to the high pH value of pasteurized milk, as well as the buffering capacity of the beverage and the presence of calcium phosphate and fluoride in its content.

Based on earlier studies on the roughness values acquired through immersion in beverages with varying pH levels, it should be considered that the type of acid used has an impact in addition to the liquid's pH value.[20,21] The citric acid contained in orange juice increases the dissolution of dental restorations due to the common ion loss effect.[22] On the other hand, Coca-Cola, which contains strong acids such as carbonic, phosphoric, and orthophosphoric acids, causes the erosion of various materials.[17,23] According to a previous studies, cola-based beverages have a higher erosive potential than orange juices immediately after exposure.[21,24] However, in our study, no significant difference has been found between Coca-Cola and orange juice in terms of surface roughness. Additionally, for the artificial saliva used as the control group in our study, Ionta et al.[25] stated that it may affect the surface roughness due to its potential remineralization properties but no statistically significant difference was observed in our study.

The surface roughness of three different fissure sealants immersed in different beverages may be related to the interaction of the beverages with carbon dioxide in the atmosphere. Elwardani et al.[24] indicated that the dissolution of carbon dioxide to create carbonic acid as a result of the interaction between distilled water and carbon dioxide was the cause of the increase in surface roughness of resin-based materials immersed in distilled water.[24]

The filler rates of the fissure sealants used in our study are as follows: 0% Cinpro, 55% Fissurit FX, and 53% UltraSeal XT hydro. Previous studies reported that surface roughness is directly impacted by the size and proportion of surface area that filler particles occupy.[20,26] However, in our study, no significant difference was observed between resin-based fissure sealants.

In the study of Hamza et al.,[27] highly filled material Grandio Seal (70%) showed statistically significantly less wear than Fissurit FX (55%). This observed difference is likely due to the higher filler content in Grandio Seal, which increases the hardness of the material. It also supports the findings of Souza et al.,[28] who found that the volume content of fillers had a significant impact on the mechanical and tribological properties of resin-based materials.

Considering the limitation of present study, the environment of the oral cavity could not be completely and accurately mimicked in vitro. Natural saliva can regulate acidity of some beverages due to its buffering effect. Additionally, some beverages can stimulate saliva flow, minimizing their negative effects on the materials under study. Therefore, additional research is required to assess the long-term clinical and in vitro performance.

Within the limitations of the current study, acidic beverages did not result in a statistically significant difference in the surface roughness of Clinpro, Fissurit FX, and UltraSeal XT hydro. However, it has been determined that the surface roughness of UltraSeal XT hydro is mathematically less. This suggests that this may be related to the chemical content of fissure sealants, the ratio of filler particles, filler particle size, and uniformity of the filler distribution.

**Ethics Committee Approval:** This paper did not need ethical approval since the author did not perform any experiments using humans or animals in it.

**Informed Consent:** For this type of study, informed consent is not required.

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