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Research Paper

Effect of fluoride-releasing fissure sealants on enamel demineralization

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ABSTRACT

Objective: The purpose of this study was to investigate the effect of three types of fissure sealant (resin-based fissure sealant, resin-based fissure sealant containing S-PRG filler, and resin-modified glass ionomer cement (RMGIC)-based fissure sealant) on the surrounding enamel.

Materials and methods: Human deciduous molars were filled with fissure sealants and cut into 200 μm sections. Using an automatic pH-cycling system, the specimens were repeatedly demineralized and remineralized for 5 weeks. After automatic pH-cycling, integrated mineral loss (ΔIML) of the enamel around the fissure sealant was calculated. Twelve blocks of each fissure sealant were exposed to 10 mL of distilled deionized water at pH 6.3. Fluoride ion release, strontium ion release, and pH changes of the water were measured every week for 5 weeks.

Results: The BeautiSealant and FujiIIILC sealant groups had a significantly lower mean ΔIML at 5 weeks than the control group. The rate of fluoride and strontium ion release was significantly greater for the FujiIIILC sealant group than that for the Teethmate F-1 2.0 and BeautiSealant groups.

Conclusion: Fissure sealants that released a lot of fluoride and strontium ions showed decreased enamel demineralization.

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1. Introduction

Dental caries is one of the most common diseases among children and is caused by acid production from oral bacteria such as *Streptococcus mutans* [1]. Deciduous teeth are more susceptible to decay because they have lower acidity resistance compared with permanent teeth. To prevent caries, it is recommended to seal deciduous teeth with fissure sealants [2]. However, fissure sealants do not provide complete protection from dental caries and secondary caries can form around the fissure sealant [3].

It is well known that topical fluoride application effectively prevents dental caries [4]. Fluoride-releasing materials such as resin-modified glass ionomer cement (RMGIC) and surface reaction-type pre-reacted glass ionomer (S-PRG) have been developed [5]. In addition, these materials also release strontium ions [6]. Fluoride and strontium ions improve the crystallinity of the tooth surface and markedly reduce their acid reactivity [7].

To perform time-lapse analysis of dental caries, an automatic pH-cycling system was previously developed [8]. This system simulated daily pH changes in the oral cavity, as illustrated through a Stephan curve [9]. Various fissure sealants are currently in clinical use. These include a resin-based fissure sealant [10], a resin-based fissure sealant containing S-PRG filler [11], and an RMGIC-based fissure sealant [12]. The bond strength [13], fluoride release [11], and clinical use [14] of these different sealants have been reported. However, little is known regarding the effect of these fissure sealants on the surrounding tooth enamel. To address this, we evaluated the effects of three fissure sealants on the surrounding enamel using an automatic pH-cycling system. In addition, we measured the fluoride and strontium ion release, change in mass, and pH of the water in which the fissure sealant block was stored.

2. Materials and methods

2.1. *Fissure sealants*

Three different fissure sealants were used: (1) Teethmate F-1 2.0 (TM; Kuraray Noritake Dental, Tokyo, Japan), a resin-based fissure sealant; (2) BeautiSealant (BS; Shofu, Kyoto, Japan), a resin-based fissure sealant containing an S-PRG filler; and (3) FujiIIILC (IIILC; GC, Tokyo, Japan), an RMGIC-based fissure sealant (Table 1).

2.2. *Preparation of the specimens for transverse microradiography*

Sixteen deciduous molars without caries were used in this study. The molars were divided into four groups: control, TM, BS, IIILC. These teeth were extracted to allow replacement by permanent teeth and stored in distilled water at 4 °C until use. They were pretreated by immersion in 2.0 N perchloric acid for 30 s to remove the surface enamel [15]. The enamel was then polished with a Robinson brush using an alumina suspension (Alpha Micropolish Alumina C; Buehler, Lake Bluff, IL, USA). Cavities (1 mm in width, 1 mm in depth, and 5 mm in length) were prepared in the buccal surfaces using a diamond point (FT90; P.D.R., Aichi, Japan) and air turbine with water. After treatment of the tooth surface in accordance with the manufacturers' instructions, the cavities were filled with the respective fissure sealants and exposed to light for 20 s. Control teeth were not filled. Teeth were then cut into 200 μm sections parallel to their long axis in the buccolingual direction using a micro-cutting machine (BS-300CP; Meiwafosis, Tokyo, Japan). Twelve sections were cut per group and the buccal surface was coated with sticky wax and a copper mesh to create a reference point on transverse microradiography (TMR) images.

This experiment was approved by the Research Ethics Committee of Hokkaido University Graduate School of Dental Medicine (2013-01). Written informed consent to use the extracted teeth was provided by patients and their parents.

2.3. *Automatic pH-cycling system*

We used a previously designed automatic pH-cycling system [8]. The pH changes in this system are shown in Fig. 1. The cycle was as follows: demineralizing solution (0.2 M lactic acid, 3.0 mM $CaCl_2$, 1.8 mM KH_2PO_4, pH 4.5) for 2 min, interval for 3 min, and remineralizing solution (0.02 M HEPES, 3.0 mM $CaCl_2$, 1.8 mM KH_2PO_4, pH 7.0) for 60 min. The average time for the pH to reach 5.5 or less (demineralization time) during each cycle was 20 min, and the average time to return to the initial pH (recovery time) was 50 min. There were six cycles per day (at 06:00, 09:00, 12:00, 15:00, 18:00, and 21:00). Specimens were immersed in the remineralizing solution when they were not subjected to pH cycling. The experimental period was 5 weeks.

2.4. *Transverse microradiography*

Specimens were imaged by TMR before the onset of the experiment, and at 1, 2, 3, 4, and 5 weeks. The same specimens

Table 1 – Materials used in this study.

Materials	Main components	Manufacturer
Teethmate F-1 (TM) Resin-based fissure sealant	TEGDMA, HEMA, MDP, MF-MMA, hydrophobic aromatic dimethacrylate	Kuraray Noritake Dental, Tokyo, Japan
BeautiSealant (BS) Resin-based fissure sealant containing S-PRG filler	UDMA, TEGDMA, S-PRG filler	Shofu, Kyoto, Japan
FujiIIILC (IIILC) Resin modified glass-ionomer-cement-based fissure sealant	Fluoroaluminosilicate glass, methacrylate ester, polyacrylic acid, distilled water	GC, Tokyo, Japan

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