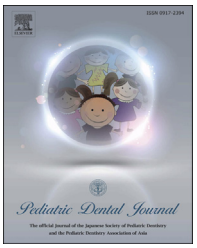
PEDIATRIC DENTAL JOURNAL XXX (2018) 1–9

Available online at www.sciencedirect.com

Pediatric Dental Journal

journal homepage: www.elsevier.com/locate/pdj



Research Paper

Material properties on enamel and fissure of surface pre-reacted glass-ionomer filler-containing dental sealant

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ARTICLE INFO

Article history:
Received 14 March 2018
Received in revised form
13 April 2018
Accepted 24 May 2018
Available online xxx

Keywords:
S-PRG
Sealant
Bond strength
Flowability

ABSTRACT

Purpose: In pediatric dentistry, sealants have been used to prevent caries. Due to its material properties such as fluoride-releasing ability and physical strength, surface pre-reacted glass (S-PRG) filler is added primarily to resin-based dental materials for clinical use. In this study, we investigated the properties of S-PRG filler containing sealant.

Methods: Before using sealant, the primer was applied to extracted bovine incisors. Scanning electron microscopy (SEM) observation revealed that the primer treatment caused no structural changes of enamel surface, unlike conventional phosphoric acid etching. Further, shear bond strength test was performed to measure the initial strength and durability after thermal cycling. Bond strength of S-PRG filler containing sealant was comparable to those of other sealants even though the former does not involve phosphoric acid etching. In addition, after treating the enamel surface with the primer or phosphoric acid, it showed excellent flowability in the primer group compared to phosphoric acid treatment.

Results: SEM observation showed that the sealant sealed the enamel surface as it migrated to reach the deep areas of the fissures. When the marginal sealing ability of the sealant was evaluated based on dye penetration, no dye penetration in the marginal region was observed in any specimens. In addition, measurement of the pH of an acid solution containing a cured specimen of the sealant containing S-PRG filler showed that the solution's pH became more alkaline as the immersion time increased.

Conclusion: These findings suggest that the sealant is an extremely effective material for preventing caries.

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https://doi.org/10.1016/j.pdj.2018.05.001

1. Introduction

Aesthetic restoration materials represented by resins have hydrophobic features because of their hydrophobic composition. On the other hand, teeth are hydrophilic as a living tissue, and except for the enamel layer in which organic components are less abundant, teeth do not provide environments that resin monomers can penetrate easily [1]. Consequently, teeth surface requires to be treated with primers containing amphiphilic monomers to create dental environments that enhance the penetration of resin monomers and ensure sufficient bond strength to the dentin [2].

Sealants used for caries prevention are broadly categorized as two types: resins and glass ionomers. Due to the hydrophobic nature of resin materials, special tools such as a rubber dam are required to exclude moisture completely when we apply resin-based sealants to pits and fissures [3–5]. However, in the pediatric dentistry fields, it is common to encounter situations that a rubber dam cannot be kept in place by the clamp due to its location, for example, primary teeth falling out and being replaced by erupting permanent teeth. In such situations, glass-ionomer sealants, which can be used after simple exclusion of moisture, are preferred to be used instead of resin-based sealants [3,6]. While glass-ionomer sealants have excellent fluoride-releasing properties, their hardness and bond strength are inferior to those of resin-based sealants [3,6–8]. Accordingly, the development of a novel material that has the advantages of both types of sealants is awaited in clinical pediatric dentistry.

While possessing physical strength comparable to conventional aluminosilicate glasses [10], surface pre-reacted glass-ionomer (S-PRG) filler (Shofu Inc., Kyoto, Japan) releases large amounts of ions such as fluoride, borate, sodium, aluminum, and silicate because of its glass-ionomer phase [10–12]. Previously, fillers were added to resin-based sealants to increase material strength, but this addition resulted in a reduction in the flowability of the sealants, compromising the ability of sealants to seal fissures [13]. In principle, no external forces (including occlusal forces) reach the depths of fissures. Therefore, priority is placed on flowability rather than material strength, and fluid resins have been used to ensure the sealing of fissures. However, despite an extremely favorable short-term prognosis, resin-based sealants fracture easily as they start experiencing external forces at the marginal region due to attrition, which often results in the development of caries at the fracture site.

In addition, soon after eruption, teeth have pre-mature enamel crystals and take up only a small amount of fluoride and thus have a high risk of caries [4]. Under such circumstances, complete sealing with resin-based sealants interferes with further crystallization on the enamel surface, and if the sealant has a defect, the dentin will be susceptible to carious lesions because of low acid resistance. Indeed, caries prevention with resin-based sealants for teeth with CO, an early carious lesion formation, has been reported to be less effective. Furthermore, etching with 37% phosphoric acid aqueous solution, which is a conventional enamel surface treatment, often evokes negative opinions when applied to healthy teeth rather than the restoration of carious teeth because of the harmful effect on the enamel surface [14]. Against this background, the clinical application of glass-ionomer sealants has been attempted because they are gentle on the enamel surface and add an acid-resistant feature to immature enamel [6].

In this study, we investigated the material properties of a dental sealant containing S-PRG filler that thus possesses the beneficial features of resin-based and glass-ionomer sealants.

2. Methods

2.1. Shear bond strength test

To evaluate the effect of primer and sealant on enamel, we used bovine enamel surface, because it is easy to prepare the plane surface and it is less individual difference between each samples compared to human tooth. To evaluate the effect of primer treatment, bovine enamel was subjected to no surface treatment, primer treatment for 3 s, or etching with 37% phosphoric acid solution for 30 s. After washing with water and air drying, uncoated specimens were examined by scanning electron microscopy (SEM; Keyence Co.). To evaluate the shear bond strength of the coating materials, bond strength testing of the enamel and cured surfaces was performed using a brass ring (2 mm in diameter). In addition, the specimens used in bond strength testing were divided into two groups: one for 24-h thermal cycling and another for 2000 thermal cycles at 4–37 °C. Sealants evaluated in shear bond strength testing were BeautiSealant, Teethmate F-1 2.0, Palfique Light Sealant, Concise™ Light Cure White Sealant, Clinpro™ Sealant, Helioseal F, Aestheseal F, FluoroSealant, DELTON FS, and FUJI III LC. Sample number of each experiments are 6 ($n = 6$). Statistical analysis was used ANOVA.

2.2. Sealing procedures

The tooth surface was cleaned using a brush cone mounted on a low-speed engine. To test BeautiSealant, the attached primer was placed in a petri dish, applied to the tooth surface for 5 s using a MicroBrush Fine applicator, left for $\geq$5 s, and air-dried for 5 s under low pressure. Then, the tooth surface was sealed with the sealant paste and illuminated for 10 s using a light-emitting diode (LED) illuminator (Solidilite; Shofu Inc.). The primer is composed of phosphonic acid monomer, carbonic acid monomer, water, solvent, and catalyst, whereas the sealant paste contains methacrylic acid monomers (urethane dimethacrylate and triethyleneglycol dimethacrylate), S-PRG filler, catalyst, and pigment. The manufacturer does not specify the amount of the above components in each product, but neither product contains 2-hydroxyethyl methacrylate. Sealing with other sealants was performed according to the manufacturer's instructions.

2.3. Flowability of sealants

Bovine incisors were subjected to no surface treatment, primer treatment for 3 s, or etching with 37% phosphoric acid for 30 s. After washing with water, 20 μL of BeautiSealant was applied gently to a site approximately 5 mm from the cervical region. Then, the incisor specimens were kept upside down,

Please cite this article in press as: Hirayama K, et al., Material properties on enamel and fissure of surface pre-reacted glass-ionomer filler-containing dental sealant, Pediatric Dental Journal (2018), https://doi.org/10.1016/j.pdj.2018.05.001