Journal of the Mechanical Behavior of Biomedical Materials 85 (2018) 117–123

Contents lists available at ScienceDirect

Journal of the Mechanical Behavior of Biomedical Materials

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

Effects of subpressure on the sealing ability of dental sealant in vitro

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ARTICLE INFO

Keywords:
Pit and fissure sealant
Subpressure
Thermocycling
Microleakage
Secondary caries

ABSTRACT

Objectives: Pits and fissures sealing with flowable materials is a popular method for preventing caries in preventive dentistry while there is still microleakage existed. This in vitro study aimed to explore the effects of subpressure technique on the sealing ability of pit and fissure sealant.

Materials and methods: One hundred and forty-one extracted human premolars were collected in this study and treated with different pressure (atmosphere pressure as group C, −0.04 MPa as group S_4 and −0.08 MPa as group S_8). Thermocycling (×5000) was also performed. Penetration percentage, microleakage, cross-sectional microhardness (Knoop, KMH) and mineral loss were evaluated. Kappa tests, Friedman nonparametric and two-way ANOVA were used for data analysis.

Results: Penetration percentages of group S_4 and S_8 were significant higher compared to that of group C. Microleakage of groups was similar before thermocycling, while subpressure groups showed lower scale of microleakage after thermocycling. Data of KMH and mineral loss showed significant differences between subpressure and thermocycling groups.

Significance: Subpressure technique could increase the penetration of pit and fissure sealant, decrease microleakage and increase resistance of demineralization after thermocycling. This novel technique may have great potential for preventing from secondary caries.

1. Introduction

Occlusal pits and fissures vary in shape but are generally narrow, with invaginations or irregularities where bacteria and food are mechanically retained. This anatomy causes high incidence of caries lesions in teeth pits and fissures (Ahovuo-Saloranta et al., 2016). Pit-and-fissure sealants are extensively used by placing a flowable material into the pits and fissures which are susceptible to caries, to form a micromechanically bonded, protective layer that acts as a barrier and prevents the accumulation of caries-producing bacteria (Soleymani et al., 2014). The application of pit-and-fissure sealant to posterior teeth is the most superior method known in dentistry to prevent term fissure caries or the progression of incipient caries (Simonsen and Neal, 2011).

The effects of sealants on decreasing the incidence of caries depend on their high penetration ability, ongoing resistance of microleakage and demineralizing, otherwise the carious process might be supported and continue underneath the sealant (Jensen and Handelman, 1980). This is especially important with questionable carious fissures, which makes the total management more difficult (De Craene et al., 1988; Weerheijm et al., 1990). Clinically, the practitioner often faces the dilemma that either to preserve apparently sound dental tissue by merely sealing the fissure, or to conduct an invasive 'biopsy' to assess the extent of caries and restore the tooth. This dilemma arises from the uncertainty about the ability of a sealant to arrest caries in a fissure, which is highly dependent on the degree of microleakage at the periphery of sealant.

Various pretreatment methods have been investigated to enhance the effectiveness and retention of sealants (Ahovuo-Saloranta et al., 2016; Simonsen, 2002). However, there is no consensus related to the best method of cleaning pits and fissures prior to applying etchant and sealant. The use of pumice slurry with rotary instruments in a low-speed handpiece to clean the tooth is the most widely accepted method (Ahovuo-Saloranta et al., 2016; Duangthip and Lussi, 2003a). Even after etching and rinsing, debris may still remain in the pits and fissures, preventing enamel conditioning and decreasing resin penetration (Brown et al., 1988; Burrow and Makinson, 1990). Recently, Zhuge reported that subpressure technique could enhance the depth of resin tags inside dentinal tube, which might also be useful in sealants (Zhuge et al., 2017).

Therefore, this study aims to investigate the effects of subpressure

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https://doi.org/10.1016/j.jmbbm.2018.05.023
Received 27 March 2018; Received in revised form 9 May 2018; Accepted 14 May 2018

technique on pit and fissure sealant from penetration percentage, microleakage and resistance of demineralizing, and to offer a novel method for better sealing ability.

2. Materials and methods

2.1. Specimen preparation and treatments

Under patients' informed consent and the approval of the local Ethics Committee, and in full accordance with the Code of Ethics of the World Medical Association Helsinki Declaration, 141 human maxillary premolars extracted for orthodontic reasons were stored in normal saline at room temperature for a maximum of 1 month before used. All teeth were devoid of any caries or anomalies. After cleaning by rubber cup and pumice powder, they were randomly assigned to three groups (C, S_4 and S_8) with 47 teeth in each group. Then they were embedded with the self-curing resin. Helioseal F (Ivoclar Vivadent AG, USA) was selected as the pit and fissure sealant. The occlusal surfaces were routinely etched with 35% phosphoric acid etchant gel for 30 s.

Group C: The teeth were carried out according to the manufacturer's instructions at atmospheric pressure and cured with a light curing unit (Elipar™ 2500, 3 M ESPE, USA).

Group S_4: A vacuum chuck of self-made subpressure apparatus (Zhuge et al., 2017) was tightly placed on the tooth surface after the sealant was applied, and then the pressure inside the chuck dropped to −0.04 MPa, holding for 15 s, curing for 20 s.

Group S_8: The teeth were treated by the same subpressure apparatus as group S_4 after applying sealant, and the pressure dropped to −0.08 MPa, holding for 15 s, curing for 20 s.

All specimens were stored in the distilled water at 37 °C for 24 h. 9 teeth of each group were randomly selected for scanning electron microscopic analysis. Then the rest teeth of each group were divided to two subgroups (n = 19 for each group): Group C_I, Group C_T, Group S_{4I}, Group S_{4T}, Group S_{8I} and Group S_{8T}. Group C_T, Group S_{4T} and Group S_{8T} were thermocycled for 5000 cycles between 5 °C and 55 °C with a dwell time of 30 s in a thermocycling machine (Temperature Cycling Chambers; TC-501F, WELL, Suzhou, China)(Ansari et al., 2004). The experimental procedures were shown in Fig. 1.

2.2. Scanning electron microscopic analysis

9 teeth of Group C, S_4 and S_8 were randomly selected and sectioned to two slices (1.5 mm thick), from the middle of central fissure in bucco-lingual direction by water-cooled diamond disk (Isomet 4000 Linear Precision Saw, Buehler, USA). 9 ideal sections of each group were observed under scanning electron microscope (Phenom-world Co., LTD., Netherlands, SEM) with magnification of 400×. The images of 2048 × 2048 pixels with a size of 536 μm × 536 μm were recorded. Multiple images were taken if the depth of fissures was out of one scanning range and the high-resolution panoramic image was made up through image mosaic. These photographs would be used to evaluate the fissure type and penetration ability.

2.3. Fissure type classification

The micromorphology of the fissure system was classified into four types according to Sutalo's study (Sutalo et al., 1989): (1) U-type; (2) V-type; (3) Y1-type; (4) Y2-type. The present study tended to select Y1 and Y2 fissure type (Fig. 2).

2.4. Filled area calculation

The entrance of the pits and fissures, defined by the distance between the two enamel surfaces, was approximately 200 μm measured perpendicular to the fissure axis (Splieth et al., 2010).

The end of the pits and fissures was defined as the bottom of fissures. If the dense debris was community on the bottom of fissure, the debris was considered as a part of enamel.

For the evaluation of penetration percentage, the filled areas (area of fissure filled by sealant) were marked in SEM images using Photoshop (Photoshop CC, Adobe Systems Software Ireland Ltd., USA). The pit and fissure areas were marked in the same way. If the pellicle and debris were surrounded by sealant, this area was considered as filled area, in opposite as unfilled area.

The penetration percentage was expressed as the percentage of filled area (%) of fissures according to Duangthip's research published in Pediatric Dentistry (Duangthip and Lussi, 2003b). The percentage value was calculated according to the following formula,

$$Penetration\ \ percentage\ \ (\%) = filled\ \ area\ \ (pixels)\ /pit\ \ and\ \ fissure\ \ area\ \ (pixels).$$

2.5. Microleakage analysis

9 teeth of each group were randomly selected and the surface of

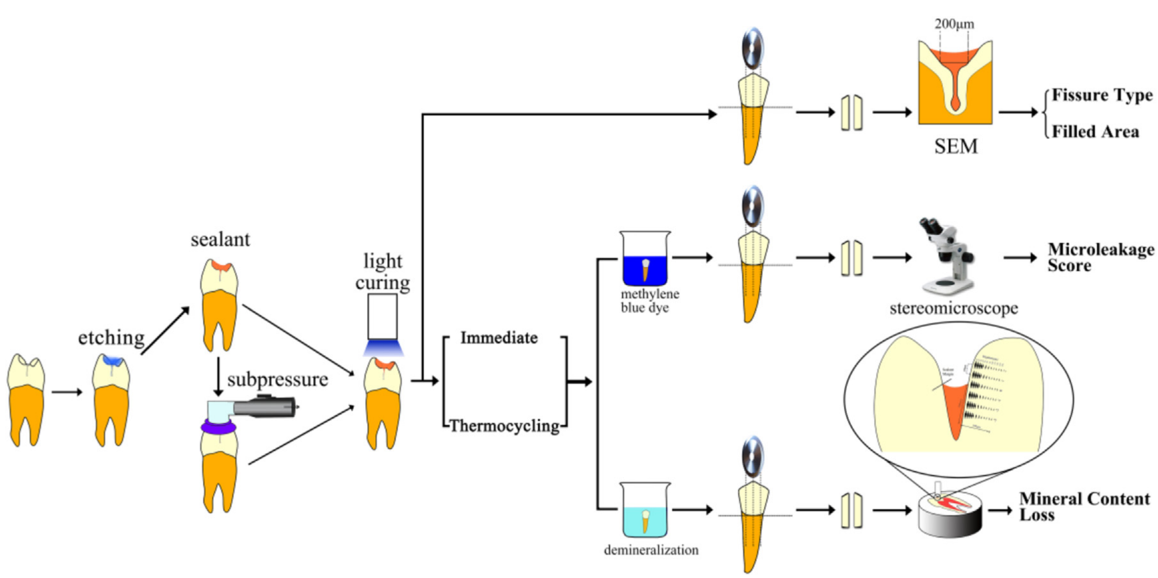

Fig. 1. Schematic diagram of this study.