

Effects of tooth preparation on the microleakage of fissure sealant

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ABSTRACT

Background: Fissure sealing can be achieved by preparing and sealing the deep pits and fissures in the teeth with a sealant to prevent caries. Fissure sealing is performed using resin modified glass ionomer cement (RMGIC) and failure is most often due to weak adhesion between the material and the tooth, resulting in microleakage. **Purpose:** The study aimed to determine the effect of a preparation technique with bur and acid application on potential RMGIC fissure sealant microleakage. **Methods:** Twenty-four extracted maxillary premolars were divided into four treatment groups. Group 1 underwent enameloplasty with a round bur and application of 37% phosphoric acid; group 2 with a tapered bur and 37% phosphoric acid; group 3 with a round bur and 10% polyacrylic acid; and group 4 with a tapered bur and 10% polyacrylic acid. The application of 37% phosphoric acid was carried out for 15 seconds, while 10% polyacrylic acid was applied for 20 seconds, before RMGIC filling. The teeth were stored in artificial saliva at 37°C for 24 hours, then thermocycled 100 times at 5°C and 55°C for 20 seconds each. The teeth were immersed in a 1% methylene blue solution for 24 hours at 37°C, then cut crosswise. The length of the microleakage was observed with a stereo microscope at 8 times magnification and measured using raster image application. Data was analysed with one-way ANOVA. **Results:** Significant differences were found between treatment groups ($F=562.14$; $p<0.05$). The deepest mean microleakage was in the round bur and 10% polyacrylic acid group (1657.87 ± 78.08) and the shallowest was in the round bur and 37% phosphoric acid group (500.70 ± 38.55). **Conclusion:** The preparation method, type of bur and acid solution have an effect on microleakage potential of RMGIC fissure sealing. Round bur preparation and 37% phosphoric acid resulted in shallow microleakage.

Keywords: preparation technique; fissure sealant; microleakage

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INTRODUCTION

Pit and fissure sealant was introduced by Buonocore in 1971. He started using an acid etch before sealing fissures for preventing caries. Various fissure sealing preparation methods were observed by Agarwal, such as air abrasion, increased etching time, air polishing, application of pumice slurry, brushing, and mechanical bur preparation.¹ Fissure sealing aims to seal the deep fissures of the teeth as a physical barrier to prevent the entry of food debris into those fissures.²

Fissure sealing is performed using a low viscosity dental material, namely resin modified glass ionomer cement (RMGIC).³ RMGIC combines the advantages of

glass ionomer materials and composite resins. RMGIC releases fluoride which can prevent and control caries. The material hardens upon light curing.⁴ Adhesion of the material will occur after the light curing process, but the literature reveal that the sealant will lose about 5-10% efficacy per year.⁵

Failure of the fissure sealant in the form of microleakage causes bacteria to easily enter through the gap and continue to develop into dental caries. As microleakage occurs due to poor adhesion of the material to the tooth, the preparation method before fissure sealing treatment needs to be considered.⁶ The adhesion and bond strength between the sealant and the tooth is influenced by the preparation of the tooth before the application of the sealant.⁷ Fissure sealing

preparation, among others, takes the form of prophylaxis with pumice, application of acid to the enamel, air abrasion, or enameloplasty. The preparation is carried out on the enamel surface prior to sealant application. Preparation can be divided into two types, namely mechanical and chemical.⁵ Chemical preparation is performed through acid application, which serves for the adhesion of fissure sealants.⁸ According to the manufacturer's recommendations, fissure sealing with RMGIC is preceded by the application of 10% polyacrylic acid to remove the smear layer.⁹ Chemical preparation can also be carried out with the application of 37% phosphoric acid to increase the mechanical strength of the sealant.⁵ Acid application on the tooth surface can form enamel micropores within which the material will form resin tags.

Mechanical preparation can create access to deep fissure areas, remove debris, enable deeper sealant penetration, and increase retention.⁵ One of the commonly used mechanical preparations techniques is enameloplasty. It is a prophylactic procedure that removes enamel in the pits and fissures of the tooth to produce a smooth and sloping surface.¹⁰ Enameloplasty is performed with a cutting instrument in the form of a bur, which can cut the enamel effectively.¹¹ Most dentists use round burs to perform enameloplasty.⁵ It can also be performed with a tapered bur, often called a fissurotomy bur. Enameloplasty can determine the penetration depth of the sealant.⁵ A combination of mechanical and chemical preparation techniques plays an important role in increasing the bond strength between the tooth and the material, which in turn can affect the success of fissure sealing.⁷ One indicator of efficacy is the microleakage test. This study aims to determine the effect of the preparation method with various bur and acid applications on the microleakage potential of RMGIC fissure sealant.

MATERIALS AND METHODS

The research protocol was reviewed by the Ethical Committee of Faculty of Dentistry and was granted ethical clearance with certificate number of 00476/KKEP/FKG-UGM/EC/2020. This experimental laboratory research included 24 extracted human maxillary premolars, free of caries. Human premolars extracted for orthodontic reasons were included in this study. The teeth were stored in a saline solution for 6 months extraction and divided into four groups (n=6 each). Teeth were randomly selected and distributed into the four experimental groups (coded 1, 2, 3, and 4). Groups 1 and 3 underwent enameloplasty

with a 1/4 round bur (SS White, Lakewood, New Jersey), 2 and 4 with a tapered bur (SS White, Lakewood, New Jersey). The depth of the enameloplasty was adjusted to the diameter and height of the bur head. Afterwards, 37% phosphoric acid (3M, Saint Paul, Minnesota) was applied for 15 seconds in groups 1 and 2, while groups 3 and 4 used 10% polyacrylic acid (GC, Tokyo, Japan) for 20 seconds. Fissure sealing was performed with RMGIC (GC, Tokyo, Japan) in all groups after acid application. The teeth were immersed in artificial saliva (MIPA UGM laboratory, Sleman, Indonesia) for 24 hours in an incubator at 37°C, then thermocycled for 100 cycles at 5°C and 55°C. The apical part of the tooth was coated with nail polish and sticky wax before immersing in a 1% methylene blue solution (Pudak Scientific, Bandung, Indonesia) for 24 hours at 37°C. The soaked teeth were cleaned from nail polish and wax, then rinsed in water. The teeth were dried and cut crosswise in the mesial-distal centre using a benchtop micro milling machine (Proxxon, Hickory, North Carolina). Microleakage was observed with a binocular microscope (Olympus, Tokyo, Japan) at 8 times magnification and measured in micrometres (µm) using Image Raster application version 3 (Miconos, Sleman, Indonesia). The data was then statistically tested with one-way ANOVA, SPSS version 22 (IBM, New York, USA).

RESULTS

The mean results obtained in each group are presented in Table 1. The deepest microleakage (mean value) was in the round bur enameloplasty and 10% polyacrylic acid application group. The shallowest microleakage (mean value) was in the group with round bur enameloplasty and 37% phosphoric acid application group.

The one-way ANOVA test was used to determine the effect of the type of bur and acid in the preparation on RMGIC fissure sealant microleakage; results can be seen in Table 2. Results show an F value of 562.14 ($p < 0.05$),

Table 1. Mean and standard deviation of RMGIC fissure sealant microleakage based on preparation method (µm)

Treatment group	n	Mean ± SD (µm)
Round bur and 37% phosphoric acid	6	500.70 ± 38.55
Tapered bur and 37% phosphoric acid	6	900.55 ± 10.53
Round bur and 10% polyacrylic acid	6	1,657.87 ± 78.08
Tapered bur and 10% polyacrylic acid	6	998.39 ± 46.29

Table 2. One-way ANOVA test between treatment groups

	Sum of square	Degree of freedom	Mean square	F	p
Between groups	4,146,928.49	3	1,382,309.49	562.14	<0.001
Within groups	49,180.03	20	2,459.00		
Total	4,196,108.52	23			

Table 3. LSD test between treatment groups

Between groups	Mean difference	p
1 and 2	-399.85	0.000
1 and 3	-1,157.17	0.000
1 and 4	-497.69	0.000
2 and 3	-757.32	0.000
2 and 4	-97.84	0.033
3 and 4	659.47	0.000

Group information:

1= round bur and 37% phosphoric acid

2= tapered bur and 37% phosphoric acid

3= round bur and 10% polyacrylic acid

4= tapered bur and 10% polyacrylic acid

so it can be assumed that the preparation method has an influence on the microleakage potential of the fissure sealant. Comparative analysis of the study groups by a post hoc LSD test (Table 3) showed significant differences ($p < 0.05$) between treatment groups.

DISCUSSION

Deep pits and fissures are a reason why teeth are prone to caries, so prevention is necessary. Fissure sealing functions as a physical barrier to the entry of food debris and to plaque retention into the dental fissures.² The material used for fissure sealing in this study is RMGIC. Excess RMGIC can bind to the hard tooth tissue directly. Mechanical (enameloplasty) and chemical (acid application) preparations in the fissure sealing procedure are carried out to reduce the possibility of microleakage.¹²

The results showed that the type of enameloplasty bur and acid application had a significant effect on the microleakage of the RMGIC fissure sealing. The shallowest leakage was observed after a preparation method using a round bur and 37% phosphoric acid. Results in this group were better than with a tapered bur and 37% phosphoric acid group due to the difference in the preparation surface area, which is wider with a round bur than with a tapered bur. It can be determined by the following calculation:

$$\begin{aligned} \text{Surface area of round bur} &= (\frac{1}{2} \times 4 \times \pi \times r^2) + (\pi \times d \times t) \\ &= (2 \times 3.14 \times 0.35^2) + (3.14 \times 0.7 \times 0.77) \times \text{mm}^2 \\ &= 2.46 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} \text{Surface area of tapered bur} &= \pi \times r \times s \\ &= 3.14 \times 0.39 \text{ mm} \times 1.86 \text{ mm} \\ &= 2.27 \text{ mm}^2 \end{aligned}$$

The fissure surface of the teeth prepared with a round bur (2.46 mm²) is wider than the surface of the fissure prepared with a tapered bur (2.27 mm²), so more resin tags will form in the sealant applied to the fissure after a round bur preparation. This is in accordance with Parihar and Paliania, stating that the number of resin tags can affect the retention of the bond between the sealant and the tooth; the higher the tagging, the stronger the bond will be.¹³ The “U” shaped fissure resulting from the round bur preparation also facilitates material filling due to the blunt fissure base. The round bur creates a fissure shape with the same diameter

from top to bottom, in contrast to the shape of the fissure after a tapered bur preparation, which gets narrower towards the bottom. This is in accordance with findings from Tzifa *et al.* that increasing the width of the fissure makes the penetration of the material more optimal.⁵

Results from this study showed that the shallowest microleakage occurred in teeth with the application of 37% phosphoric acid after preparation with a round bur, while the deepest followed the application of 10% polyacrylic acid and the use of a round bur. This is because 37% phosphoric acid can dissolve the prism core and form a type 1 enamel etching pattern, while polyacrylic acid does not change the configuration of tooth enamel.¹⁴ The enamel etching pattern produced by 37% phosphoric acid causes the filling material to enter the enamel prism, and increases the bond strength between sealant and enamel. As such, it can reduce the risk of microleakage.¹⁵ Application of 37% phosphoric acid can also produce a coarse and porous layer as deep as 5-50 μm.¹⁶ Chemical preparation with 10% polyacrylic acid only produces an average micro-tag depth of about 8.73 μm.¹⁷ The use of 37% phosphoric acid produces deeper micro-tags, so the retention and bond strength between the material and the tooth will be better than with 10% polyacrylic acid.¹⁶ Ion exchange between glass ionomer and tooth coating without a smear layer will result in a stronger bond, whereas bonding to a smear layer would mean weaker tooth structure.⁸ Hydroxyapatite in the tooth will interact with the material. Demineralisation of the dentin and the submicron interdiffusion layer creates micromechanical retention for the cement against the tooth.¹⁸

Another factor that can influence microleakage is the storage period of the tooth from extraction to study, which is different for each tooth. All research objects were obtained from the extraction of premolars within a period of 6 months with the same storage media (saline).¹⁹ According to research conducted by Secilmis *et al.*,²⁰ dental minerals can dissolve quickly in saline. The calcium mineral of the teeth will decrease with increasing storage time and cause decreasing tooth hardness, which will affect the occurrence of microleakage. Based on this research, if using the manufacturer’s recommendation of RMGIC with 10% polyacrylic acid application, mechanical preparation with a tapered bur (fissurotomy) is advised; however, for the best results, it is recommended to use RMGIC after tooth preparation with a combination of round bur and 37% phosphoric acid before sealant application.

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