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Original Article

Assessment of microleakage of few restorative materials after erosion by acidic solution

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Abstract Some restorative materials are susceptible to erosion but whether it also causes microleakage is still questionable. The aim of this study was to assess the microleakage of few restorative materials after immersion in acidic solution. Standardized 'U' shaped cavity of 4mm diameter and 2mm depth were prepared on buccal or lingual surface of 52 human premolar and molar teeth. The teeth were divided into 4 groups which contains 13 samples and 3 controls for each and were restored either with Filtek Z250 (Group 1), Fuji IX (Group 2), Fuji II LC (Group 3), or Silverfill amalgam (Group 4). All surfaces were painted with nail varnish leaving only 2mm of tooth structure surrounding the restoration before the study samples were immersed in acidic solution, lemon juice (pH 2.74) and control samples in deionised distilled water for 24 hours. Surface photos for erosion were taken before immersion in methylene blue for 7 days. After sectioning, the assessment of dye penetration was done using Leica Imaging System DMLM (Germany). Photos showed that Fuji IX demonstrated severe erosion but no obvious changes were seen on other materials. Kruskal-Wallis test indicated that microleakage between all four groups were statistically significant. The most significant difference was between Filtek Z250 and Fuji IX ($p<0.05$). Fuji IX was the most affected by the erosion process and its degree of microleakage was the most among all the materials tested.

Keywords: erosion, microleakage, restorative materials.

Introduction

The high popularity and consumption of acidic drinks and beverages globally nowadays are expected to lead to more erosion problems faced by the patients. People might also be exposed to these problems due to other intrinsic causes such as gastric reflux or bulimia. Dental erosion is defined as an irreversible loss of dental hard tissue due to a chemical process without the involvement of microorganism (Barbour and Rees, 2004). Dental erosion not only damages enamel, but also can seriously affect the restorations in general.

One of the key functions of dental restoration is to seal the exposed dentin from oral environment to prevent pulpal damage and further decay. If there is microleakage between the margin of the restoration and tooth structure, the erosive substance may dissolve and enabling acid ions to penetrate deeply into the margin. They can interact with enamel and cause secondary caries and reach dentin which causes hypersensitivity from within the cavity (Going, 1972).

Clinical performance of restorative materials is affected by erosion (Wan Bakar and McIntyre, 2008). The strong acid arriving at the tooth surface may overwhelm the buffer effect of salivary protein and increase the erosive effect (Jensdottir *et al.*, 2006). After some time, the restoration could be lost through the eroding-off the material or dislodging of the restoration due to the erosion of the surrounding tooth structure. The margin of the restoration might deteriorate after the erosion process and whether this may lead to microleakage is not known.

Thus, this study is aimed to assess microleakage of a few commonly used restorative materials after immersion in acidic solution. The materials tested were Filtek Z250, Fuji IX, Fuji II LC and Silverfill amalgam because they are widely and commonly used among dentists and dental students in the School of Dental Sciences, Universiti Sains Malaysia (USM). This is important to the dental professionals to help them choose the best material in patients with high acid exposure.

Materials and methods

This is an experimental study to assess and compare the microleakage of glass ionomer cement (GIC), resin-modified glass ionomer cement (RMGIC), composite resin (CR) and amalgam after erosion by acidic solution. PS software (Dupont and Plummer, 1997) was used to calculate the sample size using standard deviation as 2.06 following Cenci *et al.* (2005). Each group needs 13 samples and altogether 52 samples, with addition 12 samples for control.

Human molar and premolar teeth were collected according to inclusion criteria which were teeth without fillings, caries, cracks or malformations on the buccal or lingual surfaces. They were cleaned with water and calculus scaled using ultrasonic and hand scalers. The teeth were then stored in deionised distilled water (DDW), to which 1% thymol had been added as a preservative (White *et al.*, 2001). A standardized ‘U’ shaped cavity with 4mm diameter and 2mm depth was prepared at the buccal or the lingual surfaces of the crown.

The teeth were randomly divided into 4 groups of 13 study groups which contain 13 samples and 3 controls for each using the randomization method *(www.randomization.com)*. Each group was restored either with Filtek Z250 (CR), Fuji IX (GIC), Fuji II LC (RMGIC), or Silverfill (amalgam) following the manufacturer’s guidelines. For each tooth, the entire surfaces were painted with nail varnish except for 2mm area surrounding the restoration.

Samples were immersed in lemon juice solution (pH 2.74) which was checked using pH meter (pH 211 Microprocessor, UK) for 24 hours. Then the teeth were irrigated with water and dried. Control samples for each type of material were immersed 24 hours in DDW. Later, photos of the surface restorations were taken under stereomicroscope (Leica Imaging System DMLM, Germany) for 2 randomly selected samples from each group for surface assessment of erosion.

All samples were then immersed in 2% methylene blue dye solution at room temperature for 7 days. After immersion, the teeth were rinsed with distilled water thoroughly (Rajput *et al.*, 2004).

Each tooth was held with sticky wax and sectioned in the middle in bucco-lingual direction under copius water using a diamond disc (EXAKT Hard Tissue Cutter, Germany). The depth of methylene blue dye penetration was measured using stereomicroscope (Leica Imaging System DMLM, Germany). The microleakage measurement was determined by evaluating the presence of dye penetration from the cavo-survace margin towards the axial wall by two examiners. The inter-examiner reliability (ICC) was 85%. The section with higher dye penetration was used for the measurements of microleakage (Ceballos *et al*., 2001). Kruskal-Wallis test was used as comparison of microleakage among four types of restorative materials and (p<0.001).

Results

From the observation of the photos taken after 24 hours exposure to lemon juice, Fuji IX was obviously eroded (Figure 1b). Other materials tested did not show significant changes (Figures 1a, 1c and 1d). Side views for all materials were shown in Figure 2 (a, b, c and d). All material groups show no significant difference between study samples and control samples (Table 1). Descriptive statistics for all samples are shown in Table 2. The result of the Kruskal-Wallis test for the microleakage after immersion in the methylene blue solution between all four groups were found to be statistically significant at $p<0.001$ (Table 3). Follow-up tests were conducted to evaluate pairwise differences among the four groups using the Mann-Whitney U test. The results of these tests indicate a significant difference between the Filtek Z250 restored group and other materials ($p<0.05$) (Table 4). Similarly, the microleakage was significantly difference between the Fuji IX and Fuji II and Silverfill amalgam (Table 5). However, there was no significant difference between Silverfill amalgam restored group and Fuji II LC restored group ($p>0.05$) (Table 6).

Table 1 Comparison of microleakage between study and control samples for different materials

Materials	Mean (SD) Group 1 (study)	Mean (SD) Group 2 (control)	Mean Differ. (95% CI)	*t* statistic (df)	*p* value[a]
Filtek Z250	434.8454 (292.51646)	181.9967 (68.02886)	252.84872	1.451 (14)	0.135
Fuji IX	2837.3354 (519.31753)	1952.3667 (454.63755)	884.96872	2.706 (14)	0.549
Fuji II LC	1037.3492 (410.14771)	968.0667 (686.95175)	69.28256	0.235 (14)	0.198
Silverfill amalgam	734.8262 (434.40922)	1025.5233 (312.10536)	-290.69718	-1.083 (14)	0.477

[a] independent *t*- test, * $p<0.05$

Table 2 Descriptive statistics of study samples

Restorative material	n	Depth of dye penetration Mean(SD)	Depth of dye penetration Median(IQR)
Filtek Z250	13	434.8 (292.5)	312.5 (285.5)
Fuji IX	13	2837.3 (519.3)	2758.4 (812.0)
Fuji II LC	13	1037.4 (113.8)	1175.7 (620.2)
Silverfill amalgam	13	734.8 (434.4)	598.9 (681.9)

Table 3 Comparison of microleakage among four different groups of restorative materials after acid exposure

Group	n	Median(IQR)	χ^2 statistic (df)[a]	*p* value[a]
Filtek Z250	13	312.5 (285.5)		
Fuji IX	13	2758.4 (812.0)	36.263 (3)	0.000*
Fuji II LC	13	1175.7 (620.2)		
Silverfill amalgam	13	598.9 (681.9)		

[a] Kruskal-Wallis test, *$p<0.001$

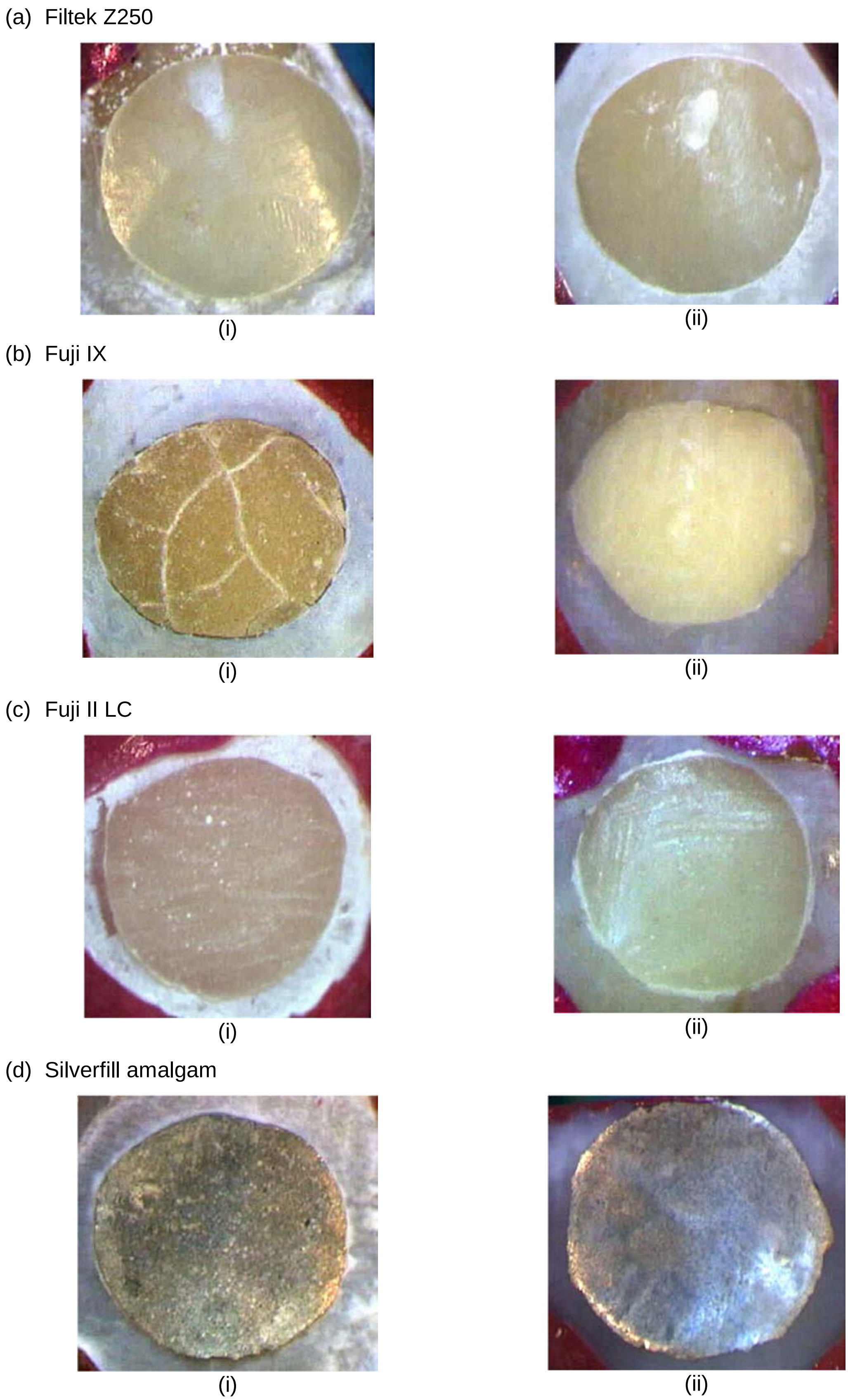

Figure 1 Surface photo of the restoration materials, (a) Filtek Z250, (b) Fuji IX, (c) Fuji II LC and (d) Silverfill amalgam after immersion in acidic solution (i) test sample; (ii) control sample.

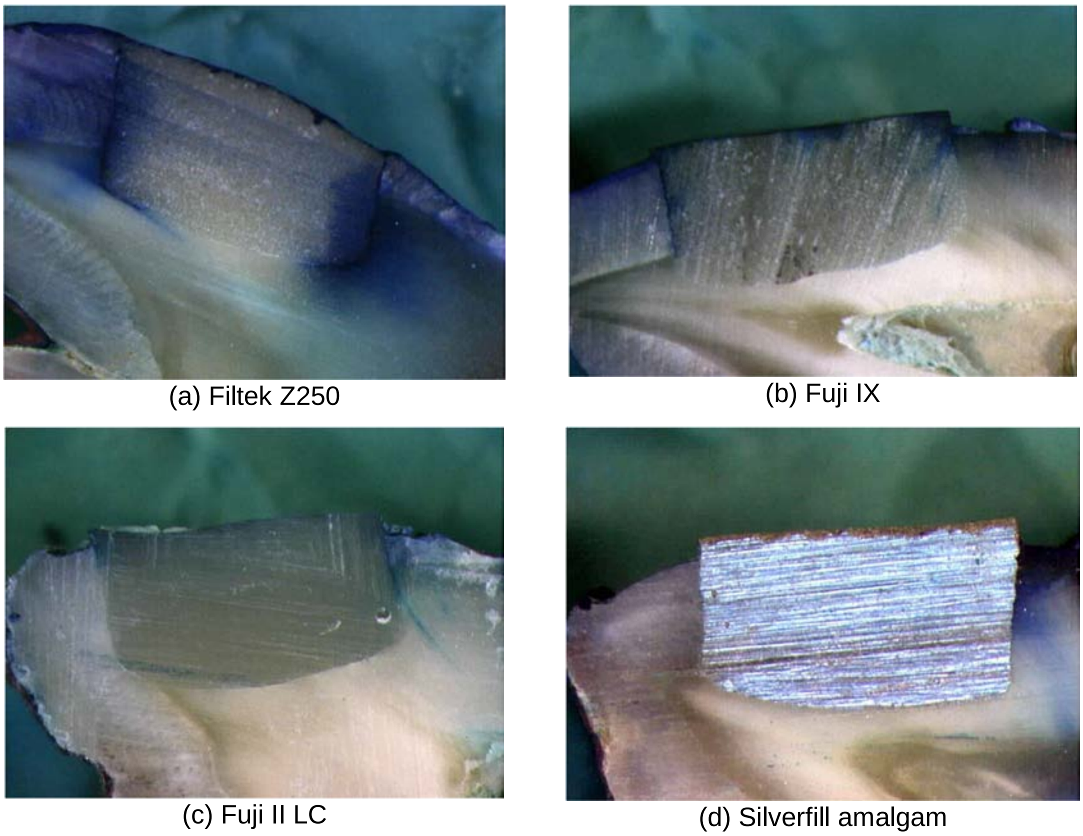

Figure 2 Restoration materials (a) Filtek Z250, (b) Fuji IX, (c) Fuji II LC and (d) Silverfill amalgam after immersion in acidic solution and methylene blue dye.

Table 4 Comparison of microleakage between Filtek Z250 and other materials after acid exposure

Materials	n	Median (IQR)	Z statistic	*p* value [a]
Filtek Z250	13	312.47 (285.48)	-	-
Fuji IX	13	2758.35 (812.02)	-4.336	.000*
Fuji II LC	13	1175.71 (620.19)	-3.618	.000*
Silverfill Amalgam	13	598.87 (681.93)	-2.027	.043*

[a] Mann Whitney test, * *p* value <0.05

Table 5 Comparison of microleakage between Fuji IX and other materials

Materials	n	Median (IQR)	Z statistic	*p* value [a]
Fuji IX	13	2758.35 (812.02)	-	-
Fuji II LC	13	1175.71 (620.19)	-4.333	.000*
Silverfill Amalgam	13	598.87 (681.93)	-4.333	.000*

[a] Mann Whitney test, * *p* value <0.05

Table 6 Comparison of microleakage between Fuji II LC and Silverfill amalgam

Materials	n	Median (IQR)	Z statistic	*p* value [a]
Fuji II LC	13	1175.71 (620.19)	-	-
Silverfill Amalgam	13	598.87 (681.93)	-1.615	.106*

[a] Mann Whitney test, * p value < 0.05

Discussion

Erosion is known to cause loss of dental hard tissue and might severely affect some of the restorations. However, little is known about the potential of erosion in the development of microleakage among different restorative materials. It is questionable whether restorative materials that are less affected by erosive process will develop low or more degree of microleakage.

From the result, it is showed that Filtek Z250 had significantly lower degree of microleakage compared to Silverfill amalgam, Fuji II LC and Fuji IX after acid exposure. This might be due to the mechanical bonding properties of composite resin on etched enamel surface. This strong mechanical bonding obtained via impregnation of resin tag into etched enamel surface (Hotz *et al.*, 1977). Studies found that the strength of the composite to enamel bond is considered to be the best tooth-restorative bond (Barkmeier *et al.*, 1986; Swift and Cloe, 1993). Thus, it is not surprising when the results of this study also demonstrate that composite resin is superior to other restorative materials tested.

GIC restoration also had been suggested to treat erosion lesion. But due to its weaker strength, this material will be easily eroded which has been similar to the finding in this study. In spite of being known to be able to bond chemically through ionic exchange with mineralized tooth structure; as well as creating ‘mountain formation’ at the margin (Dalidjan *et al.*, 2002), differently in this study, the degree of microleakage in Fuji IX after acid erosion was significantly higher than any other restorative materials tested. This may be due to acid strength which erodes the margin and cause microleakage. Previous study by Wan Bakar and McIntyre (2008) also showed that the degradation at the margin of Fuji IX (conventional GIC) is more than at their body. The degree of microleakage for RMGIC after acidic exposure is significantly lower than conventional GIC might be related to their development that improved resistance to microleakage (Martin and O’Rourke, 1993) together with the on-command hardening and immediate finishing similar to other composite resins (Chuang *et al.*, 2001). RMGIC also has improved mechanical properties and translucency as well as reduced in water sensitivity (Saito *et al.*, 1999). The degree of microleakage in RMGIC also showed no significant differences with amalgam which is known to have minimal degree of erosion.

From the observations of this study, amalgam is the material that was being less eroded after the immersion in the lemon juice. It can be clearly seen from Figure 2(d) that bulk of amalgam has remained above the level of enamel surface after the immersion. Even though the amalgam has high strength and resistant to erosion, it still has a high degree of microleakage after exposure to acidic solution. Factors that can cause microleakage includes polymerization shrinkage of adhesive restorations (Rees and Jacobsen, 1989), thermal expansion and water absorption (Retief, 1994), mechanical loading (Trowbridge, 1987; Hilton, 2002) and manipulation of materials by operators. The level of compatibility of restorative materials to tooth substances is also an important factor in microleakage generation.

Conclusion

Filtek Z250 has significantly lower degree of microleakage after acid exposure compared to GIC, RMGIC and amalgam. With this evidence, composite resin restoration can be implemented in treating erosion lesion without compromising the risk of microleakage. With a decrease in microleakage, this may reduce post-operative sensitivity and secondary caries. Conventional GIC is highly degraded by erosion and exposed to high microleakage level, therefore it is not recommended in patients with higher consumption of acidic solution. It is recommended in a future study to assess microleakage when using combination of GIC and CR and also in amalgam restoration when using amalgam bonding agent.

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