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EFFECT OF DIFFERENT NUMBER OF THERMAL CYCLING ON MARGINAL LEAKAGE OF CLASS V RESTORATION USING NANO TOOTH COLOURED MATERIALS

(EFEK SUHU YANG BERBEDA TERHADAP KEBOCORAN MARGIN TAMBALAN KELAS V DARI BAHAN PEWARNA GIGI *NANO TOOTH COLOURED MATERIALS*)

Mong, Yun Hao, Ab Ghani, Zuryati and Masudi, Sam'an Malik

School of Dental Sciences, Universiti Sains Malaysia
USM Health Campus, 16150 Kubang Kerian, Kelantan, Malaysia
Email: zuryati@kb.usm.my

Abstract

Nano tooth coloured materials may have been produced as an ideal restorative material, however, thermally induced stresses may lead to microleakage between restorative material and tooth structure which may cause unwanted complications. Thermocycling has been an important method to emulate the thermal changes of the oral cavity. This study was aimed to investigate the effect of increasing number of thermal cycles on marginal leakage of nano tooth coloured materials. A total of 56 Class V cavities was prepared on the buccal surface of the extracted single rooted human premolars and restored with either Filtek Z350 (3M-ESPE, USA) or Ceram X (Dentsply, Germany). The samples were then divided into four groups with (n=7): 1) 0 thermocycle, 2) 500 cycles, 3) 5,000 cycles and 4)10,000 cycles. All samples were immersed in 2% methylene blue dye for 4 hours at room temperature, sectioned and viewed under stereomicroscope for dye penetration. Data were analyzed using T-test and One-way ANOVA and Post-hoc Scheffe with $p<0.05$ considered to be significant. Microleakage was only evident in both materials at 5,000 cycles above. The results showed that there was a significant difference in microleakage between 5,000 and 10,000 cycles for both materials (Filtek Z350: $p<0.001$; Ceram X: $p<0.001$). However, there was no significant difference in microleakage between Filtek Z350 and Ceram X at 5000 cycles ($p=0.194$) and at 10,000 cycles ($p=0.499$). As conclusion, microleakage increases with the duration of thermal cycling in both nano-tooth coloured materials. Both materials showed similar pattern of microleakage when challenged to a higher number of thermal cycles.

Key words: microleakage, thermocycling, dental nano composite

INTRODUCTION

Tooth coloured materials had come a long way since silicate was firstly used and only recently, nano filled composites and other nano filled tooth coloured materials are introduced into the market. Produced as ideal restorative materials, manufacturers claimed it had the ability to resist stresses that are present in the oral environment and protect the interface between the tooth and the restorative materials[1]. Yet, thermally induced stresses may lead to gap formation, known as microleakage at the interface due to the mismatch of coefficient between the restorative material and natural tooth structure. Microleakage has been recognized as a major clinical problem as it contributes to more than 30% of replacement of composite restoration. Marginal leakage of a restoration can cause marginal staining, post operative sensitivity, pulp pathology and secondary caries[2,3].

Thermocycling has been an important method to emulate the thermal stress of the oral cavity *in vitro* study[2,4]. The numbers of thermal cycles simulate the length of time a particular restoration presents in the oral cavity. Some might argue regarding the validity of many studies as the samples used had not been challenged with thermal stresses long enough as they would occur naturally in the oral cavity naturally. Studies that used higher number of thermal cycles have shown evidence of microleakage on their restorations. Many studies had shown various results of microleakage on tooth coloured restorations. Some had exhibited significant microleakage even at relatively few thermal cycles[5,6]. Some had shown relatively extensive microleakage, such as Ketac-Fil and a composite resin restoration using 3 bonding systems at 3800 cycles between 5ºC and 55ºC; restoration with Silux material and Ketac Bond for 5000 cycles between 10ºC and 50ºC. Yet, other study showed there were no microleakages found on Photac-Fil and Ketac-Fil restorations after 2500 cycles.

On the other hand, other factors such as restoration techniques, materials and tooth structures may have influenced the outcome of the microleakage. Composite restorations are particularly technique sensitive as access and moisture are important control factors [7]. Higher filler loading in the tooth coloured materials may reduce the mismatch between the composite and the tooth structure which may be responsible to diminish the effect of thermocycling on microleakage scores. With regards to the type of tooth structure (enamel/dentin), dentin margin of the preparations may leak significantly more particularly after thermal cycling[4].

There have been contradictory reports over duration of thermal stress against the degree of marginal leakage of composites in previous studies. Furthermore, very few studies have been carried out to test the optimal thermal cycle numbers that a restoration should be challenged to, in order to simulate the certain length of time which is present in the oral cavity. Therefore, this study was conducted to explore the effect of different thermal stresses on marginal leakage of nano filled tooth coloured materials. The general objective of this study was to investigate the effect of different thermal cycles on the marginal leakage of nano filled tooth coloured dental materials. The specific objective was to compare the effect of 500, 5000 and 10000 thermal cycles on marginal leakage of Class V restored with two nano filled tooth coloured restorations.

MATERIALS AND METHODS

A total number of 56 sound extracted human premolars were used in this laboratory experimental study. The teeth was selected based on the following criteria: (1) normal size and shape of crown and root, (2) single rooted and (3) similar dimension by measuring the bucco-lingual/mesio-distal widths in millimeters with a 10% standard deviation from mean[5]. PS Software (Dupont and Plummer, 1997) was used to calculate the sample size based on comparing 2 means. The selected teeth were cleaned and stored in normal saline solution before being used in the study.

A standardized Class V cavity was prepared manually using high-speed handpiece (SN: 05F1150, Blen Air, Switzerland) with a diamond pearshaped bur (830.012, F 50752, Edenta AG, Switzerland) on the buccal surface of each premolar tooth with the mesio-distal width of 4 mm; the occlusogingival width and axial depth were approximately 2 mm. Each bur was replaced with a new bur after 5 preparations.

The teeth were distributed into 2 groups:

a) G1 – 28 teeth were restored with Filtek Z350 (3M ESPE, USA) with the basic composition.
b) G2 – 28 teeth were restored with Ceram X (Dentsply, Germany) with the basic composition.

All teeth were restored according to manufacturer's instructions. In G1, the cavity was air dried, then acid etched, with Scotchbond Etchant (LOT 8MP, 2011-09) (3M ESPE, USA) using microbrush for 15 seconds be-fore rinsing with water for 10 seconds. The cavity was then air dried, then Adper Single Bond 2 Adhesive (LOT 7MM, 2010-08.51202) (3M ESPE, USA), was applied with microbrush and was light cured for 20 seconds. Filtek Z350 (3M ESPE, USA) Shade A2 was then filled into the cavity increment-tally about 1 mm depth and light cured for 20 se-conds for each fill. Completed restoration was then polished with white stone.

In G2, the cavity was air dried before application of Scotchbond Etchant (LOT 8MP, 2011-09) with microbrush for 15 seconds. The cavity was then rinsed with water for 10 seconds, and air dried. Prime & Bond NT (Dentsply, Germany) was then applied with a microbrush and light cured for 20 seconds. Then, Ceram X Monophase (Dentsply, Germany) Shade A2 was filled incrementally about 1 mm depth and light cured for 20 seconds for each fill. Completed restoration was then polished with white stone.

The two groups of restored samples were then subdivided into no thermal cycle, 500 thermal cycles, 5000 thermal cycles and 10000 thermal cycles, sub-groups. Thus, each subgroup would contain 7 samples (n=7). The teeth were subjected to thermal cycling of 5ºC to 55ºC with each submersion of dwell time 30s, and transfer time of 20s between each bath.

All restored teeth including control samples were coated with an acid-resistant protective nail varnish except for a window including the restoration and a 1 mm area around it. The windows were prepared by placing strips of an adhesive tape, each measureing 4 mm in width in the occlusocervical direction and 8 mm in length in the mesiodistal direction. The specimens were immersed in 2% methyllene blue dye at room temperature for 4 hours. Upon removal from the dye solution, the specimens were gently washed with tap water[6].

Each tooth was sectioned buccolingually with the restoration at the centre using a hard tissue cutter (Exact, Japan). The distances of dye penetration were measured under stereomicroscopy (Leica, Germany).

Data collected was analyzed using SPSS version 12.0 (SPSS Inc, 2003). All statistical analysis was conducted at a significant level of $p<0.05$ using one way ANOVA with post hoc Scheffe and independent T-test.

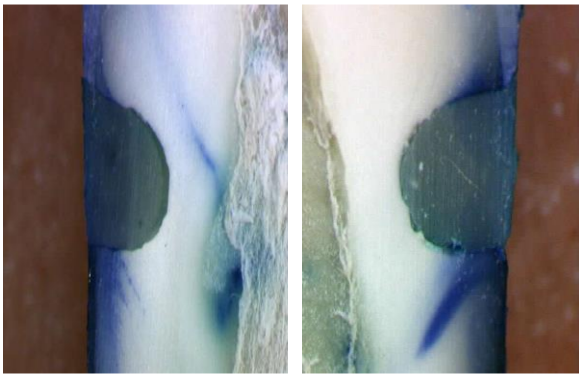
Ethical consideration was obtained from the Human Research & Ethics Committee of USM [USMKK/PPP/JEPeM-213.3(15)]. All information was kept confidential and only accessible to researchers, and only group information was reported and published.

RESULTS

The results from microleakage value in each material at 0 and 500 cycles showed that there were no microleakages in both materials (Table 1). In the mean time, there were significant microleakage values ($p<0.001$) at 5000 and 10000 cycles for each of the materials when analyzed with one way ANOVA. Through post hoc analysis, the 10000 cycles produced the most significant microleakage ($p<0.001$) for both Filtek Z350 and Ceram X.

Figures 1 illustrate the dye penetration in the dentine to simulate microleakage in Filtek Z350 and Ceram X respectively at 10000 cycles.

When comparing microleakage value in Filtek Z350 and Ceram X, there were no significant differences between the two materials at 5000 cycles ($p=0.194$) and at 10000 cycles ($p=0.499$) (Table 2).



A. Filtex Z350 B. Ceram X

Figure 1. Dye penetration in the dentine to simulate microleakage in Filtek Z350 and Ceram X at 10000 cycles

Table 2. Comparison of mean (SD) of dye penetration in mm for Filtek Z350 and Ceram X at 5000 and 10000 thermal cycles.

Thermal cycle	Filtek Z350 (3M ESPE, USA)	Ceram X Mono (Dentsply, Germany)	*p*-value
5000	0.747(0.090)	0.822(0.191)	0.194
10000	1.039(0.068)	1.020(0.075)	0.499

DISCUSSION

Thermocycling is a method widely used in dental research, particularly when testing the performance of adhesive materials *in vitro*. It aims at thermally stressing the adhesive joint at the tooth/restoration

Table 1 Comparison of mean (SD) of dye penetration in mm after 0, 500, 5000, 10000 thermal cycles, Filter Z350 and Ceram X.

Materials	No Thermal Cycles (control)	500 Thermal Cycles	5000 Thermal Cycles	10000 Thermal Cycles	*p*-value
G1 – Filtek Z350 (3M ESPE, USA)	0.0 (0.0)	0.0 (0.0)	0.747 (0.090)	1.039 (0.068)	<0.001
G2 - Ceram X Mono (Dentsply, Germany)	0.0 (0.0)	0.0 (0.0)	0.822 (0.191)	1.020 (0.075)	<0.001

interface by subjecting the restored teeth to extreme temperatures compatible with temperatures encountered intraorally[6]. There are many thermocycling regiments used, vary in terms of cycles, the extreme temperature, dwell time and submersion time. The choice of extreme temperature of 5ºC and 55ºC is based on the lowest and the highest temperature that an average person can adapt intra orally and such regiment has been used in several studies.[5,6] The number of thermal cycle used in this study was based on the proposal of an average of 20-50 times of oral environment changes in a day. This gives a simulation of 10000 cycles in a service year. Thus, the samples that have undergone 5000 cycles and 10000 cycles are to simulate an oral environment of 6 months and a year. Test of 500 thermal cycles are generally conducted to serve as a baseline, as proposed by many studies previously. Ideally, a restoration should last as long as possible in the oral environment and *in vitro* study should simulate a certain length of time in the oral environment. However, with the limitation of time and cost, it was only possible to simulate up to 10000 cycles in this study.

Class V preparations were used because they have a high C-factor design [preparations with high ratio of bonded "flow-inactive" to free "flow-active" surfaces][4]. Thermal cycling highlights the mismatch in thermal expansion between the restoration and tooth structure. Repetitive shrinkage and expansion stress on tooth and restorative material resulting fatigue of the adhesive joint with subsequent microleakage. The results of the current study showed that thermocycling enhances the process of microleakage, as specimens showed an increasing in the leakage with increased cycles (Table 1). This is in agreement with Hakimeh et all. which showed that thermal cycling had a pronounce effect on the class V compomer restoration after 2880 cycles[2]. Our study recommends the need of more than 500 thermal cycles to create microlea-kage, contradicting other reports that small numbers of thermal cycles are sufficient to induce micro-leakage. Wahab et all. showed that there were 70.8% and 79.8% of the class V preparations that showed microleakage scores at the enamel and dentin margins of the preparations respectively after 500 cycles of thermal cycle[4]. However, in that study, 6 types of mirofilled and hybrid composites were used, compared to this study which utilized nano filled composite (Filtek Z350) and nano ceramic restorative material (Ceram X). This difference may probably be attributeed by the low polymerization shrinkage properties of the nano tooth coloured material[8-10].

Comparison between dentin marginal leakage between Ceram X and Filtek Z350 showed there was no significant difference between the two materials. In previous studies, 2-year clinical evaluation showed both types of restorative materials (Ceram X and Filtek Supreme) were in good performance. A 2-year clinical evaluation of Ceram X showed there were no postoperative sensitivity, no secondary caries and minimal loss of marginal adaptation [13% of the restorations have their margins slightly caught by explorer][8]. These results were attributed by the effectiveness of the adhesive system and the low polymerization shrinkage of the restorative materials preventing cuspal fracture. The high mechanical properties prevented the pumping action of the dentinal fluid, which may explain the lack of post-operative sensitivity after 2 years[8]. However, Wahab et all. showed that different types of composite used had no significant difference in microleakage[4]. Five out of six types of composite material used showed a similar performance in class V preparation although the composition and the filler type varied considerably.

As conclusion, within the limitations of the study, longer duration of thermal cycling would increase the degree of microleakage of Class V nano filled tooth coloured materials. Both nano tooth coloured materials showed similar pattern of microleakage when challenged to higher cycles of thermal stress.

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