Using of dentin conditioner prior to placement of resin modified glass ionomer as a base in high C-factor Class V resin composite restoration.

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ABSTRACT

This in vitro study aims to evaluate the microleakage of high C-factor Class V resin composite restorations with and without surface pretreatment, using a dentin conditioner, prior to placement of resin modified glass ionomer base. Twenty non-carious human third molars were used. A box-shaped, 5x3x2.5 mm^3, Class V cavity preparation was placed on buccal surface at the cementoenamel junction. Teeth were then randomly assigned to 2 experimental groups (n=10): group 1 (NDA), Resin modified glass ionomer (RMGI) (Fuji II LC; GC Corporation, Japan) base.; group 2 (DA), RMGI base with use of Cavity Conditioner (GC Corporation, Japan). After placement of RMGI base covering whole dentin surface, the prepared cavities were etched, with selective enamel etching, and the adhesive (Scothbond Universal, 3M ESPE, USA) were then applied according to manufacturer's instructions, then restored with resin composite (Filtek™ Z350 XT, 3M ESPE, USA). The restorations were finished and polished, thermocycled (10,000×, 5-55°C) and stained with a 50% silver nitrate solution. After being sectioned bucco-lingually, 6 surfaces of measurement per tooth were obtained, and depth of dye penetration recorded. Microleakage data were analyzed using a Mann-Whitney U test. For gingival margin, group DA showed statistically significant less microleakage than group NDA ($P<0.001$). While at occlusal margin, no significant differences were detected for microleakage score between NDA and DA ($P = 0.247$). In conclusion, based on our findings, the use of dentin conditioning prior to placement of RMGI, as a base or intermediate layer, improved marginal integrity of a high C-factor resin composite restoration.

Keywords: Dentin conditioner, Marginal integrity, Microleakage, Resin modified glass ionomer base

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Introduction

Dental adhesive restorative materials have now become a mainstream of direct restorative method. This has come about with the development of a wide variety of materials exhibiting improved physical properties, reduction of technique sensitivity, and importantly, the development of excellent, reliable adhesive resins to bond filling materials to enamel and dentin surfaces [6]. The use of resin composites allows less tooth structure removal with reduced preparation sizes and also helps reinforce the remaining tooth structure [28]. However, resin composites inherit some undesirable characteristics, such as polymerization shrinkage which could jeopardize marginal integrity of the restoration, in particular, when restoring cavities with high C-factor which yield less chance for relaxation of shrinkage stress [24]. Such pre-stressed interfaces may be more susceptible to bond degradation which would explain the relatively fast in vivo bond degradation noted for high C-factor Class-I restorations even when the predicted durable bonding was being used [24]. Conversion of resin monomers into long chains of polymer leads to a loss in volume, which induces shrinkage stresses in the restoration. These stresses have the potential to initiate gap formation at the restoration–tooth interface leading to microleakage, which could resulted in marginal discoloration, post-operative sensitivity, and eventually adhesive failures [13,25,28].

The factors ascribed to marginal microleakage are the adhesive bond strengths to different dental substrates which depend on the histological and morphological characteristics of the enamel, dentin/cementum [3]. In Class V composite restoration, bonding to dentin at the cervical wall can be a problem since adhesion to dentin is more difficult. This restoration–tooth interface is where microleakage is most likely to occur.

Many techniques and newer materials have been introduced to reduce polymerization stress, such as incremental layering technique, soft-start polymerization, and the use of low modulus of elasticity liner as an intermediate layer between restoration and tooth structure [4,21,25]. Currently, glass ionomer-based materials are being used as an intermediate layer between restoration and tooth structure. Resin modified glass ionomer (RMGI) materials, which become quite popular, would act on strain and marginal leakage reduction, presenting additional benefits of adhesion to dentin and fluoride release, which may prevent secondary caries formation in composite restorations [14,18]. These bases provide better adaptation and act as a flexible stress-absorbing layer between restoration and tooth [21,25]. Several in vitro studies have shown that the application of such layer reduces microleakage and leads to an improved marginal quality [15,18,28]. Though RMGI cement can adhere to tooth structure without any prior treatment, studies have reported improvements in bond strength after surface treatment (conditioning) with various solutions [17,23,27].

From a clinical perspective, some authors suggested that the use of cavity bases would have a weakening effect on the overall strength of the restoration, resulting in more fracture of composite restorations, but has stated that the role of glass ionomers in the fracture behavior remained unclear [7,18]. The possible reason could be that a layer with a low elastic modulus (E-modulus) material placed between two high E-modulus materials (tooth and composite resin) leads to a concentration of forces in the elastic layer when the tooth is loaded [26], which could result in restorations placed with a lining being more sensitive to fatigue after repeated loading and led to higher clinical failure of the restorations due to fracture [18].

The aim of the present study was to investigate whether or not using a dentin conditioner prior to placement of a resin modified glass ionomer base would improve marginal integrity of a high C-factor Class V resin composite restoration.

Materials and methods

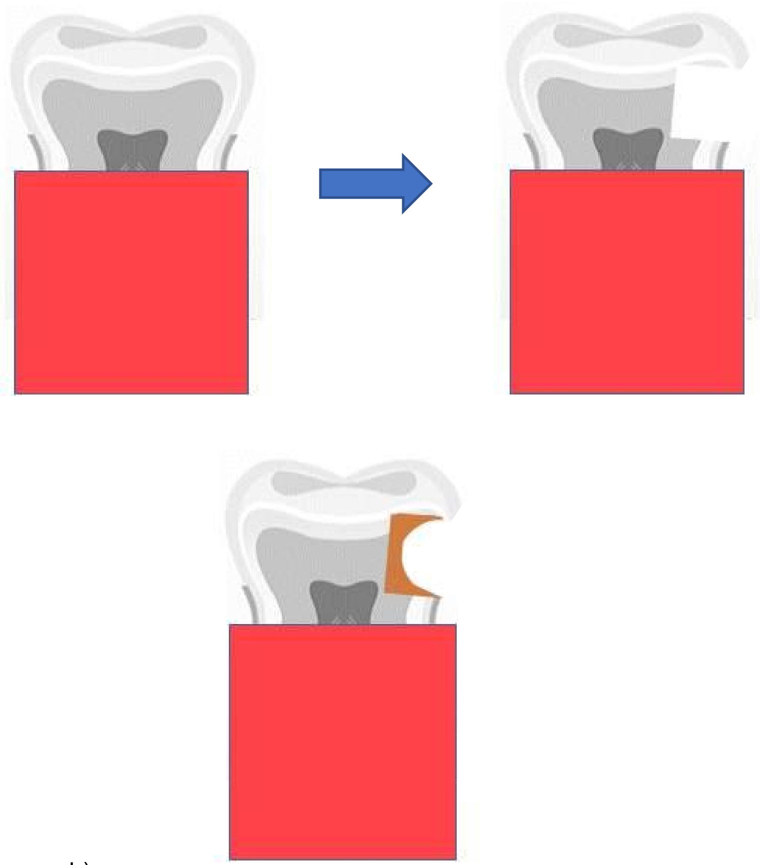
Twenty extracted sound human third molars were used in this study. The sample size of 10 per group was based on previous studies which evaluated microleakage in composite restoration [5,9,20].

The study protocol was approved by the Ethics Committee of the Faculty of Dentistry, Chulalongkorn University (HREC-DCU 2017-068). All teeth were gathered following informed consent. The teeth were cleaned with pumice and store in a 0.1% Thymol solution at $4^{o}C$ and were used within 1 month after extraction. All teeth were then mounted in 2.5x2.5x2 cm^3 acrylic blocks (occlusal surface perpendicular to the long axis), exposing 2 mm below the CEJ. A standard high C-factor class V cavity was prepared on buccal surface of each tooth. The preparations were done with high speed diamond burs under copious water coolant. After every five preparations, the burs were discarded and replaced with a new one. The gingival cavosurface margins of the preparation were placed at the cementoenamel junction. The dimension of final preparation was 3.0 mm occlusogingivally, 5.0 mm mesiodistally and 2.5 mm deep. The occlusal cavosurface margins of the preparation were beveled (Figure 1a). The specimens were then randomly divided into two groups (n=10 per group). The materials used in this experiment were listed in table 1.

Table 1: Material, Manufacturer and Component

Material	Components
Scothbond Universal (3M ESPE, USA)	1. Etchant: 34% phosphoric acid, water, synthetic amorphous silica, polyethylene glycol, aluminium oxide. (Scotchbond Universal Etchant) 2. Adhesive: MDP phosphate monomer, dimethacrylate resins, HEMA, methacrylate-modified polyalkenoic acid copolymer, filler, ethanol, water, initiators, silane
Resin modified glass ionomer (RMGI) Fuji II LC (GC Corporation, Japan)	**Powder**: 100% Fluoro-alumino-silicate glass **Liquid:** 35% HEMA, 25% Distilled water, 24% Polyacrylic acid, 6% Tartaric acid and 0.10 camphorquinone
Cavity Conditioner (GC Corporation, Japan)	20% Polyacrylic acid
Filtek™ Z350 XT (3M ESPE, USA)	BIS-GMA, BIS-EMA, UDMA, and TEGDMA, 5–20 nm Zr/silica nanoparticles + 0.6–1.4 m nano-clusters (82% wt)

HEMA: Hydroxyethyl methacrylate; Bis-GMA: Bisphenol A-glycidyl methacrylate 2,2-bis [4-(2-hydroxy-3-methacryloxypropoxy) phenyl] propane; TEGDMA: Triethyleneglycol dimethacrylate; UDMA: Diurethane dimethacrylate; GPDM: Glycero-phosphate dimethacrylate; PAMM: Phthalic acid monoethyl methacrylate



a)

b)

Figure 1 a) Cavity preparation 5x3x2.5 mm^3 with beveled enamel margin

b) Base material covering all dentin surface

Group 1 (NDA) — A 1-mm-thick RMGI (Fuji II LC, GC Corporation, Japan) was applied as base, covering whole dentin surface on the axial wall up to surrounding walls (Figure 1b), then light cured for 30s. Bonding procedures were carried out according to the manufacturer's instructions. The prepared cavities were etched, with selective enamel etching, using a 34% phosphoric acid (Scothbond Universal Etchant, 3M, USA) for 15 s, rinsed thoroughly with distilled water for 10 s, and air dried for 2 s. Adhesive (Scothbond Universal, 3M ESPE, USA) was then applied to the entire preparation with microbrush using rubbing motion for 20 s. A gentle stream of air was blown over the liquid for about 5 s until no fluid movement was observed and the solvent has evaporated completely then light cured for 10 s (Demi^{TM} Plus; Kerr, USA) with 1,100 mW/cm^2 intensity. The cavity was then filled with Filtek Z350 XT shade A3 (3M ESPE, St Paul, MN, USA) incrementally with each layer not exceeding 2 mm and light cured for 20 s.

Group 2 (DA) — A dentin conditioning agent (Cavity Conditioner, GC Corporation, Japan) was applied to dentin surfaces for 10s using a sponge, rinsed thoroughly with water, and dried. A 1-mm-thick restorative type RMGI (Fuji II LC, GC Corporation, Japan) was applied as a base on the axial wall up to surrounding walls covering whole dentin surface, then light cured for 30s. Bonding procedures were carried out according to the manufacturer's instructions same as in group 1. The cavity was then filled with Filtek

Z350 XT shade A3 (3M ESPE, St Paul, MN, USA) incrementally with each layer not exceeding 2 mm and light cured for 20 s. The teeth were then stored for 24 h at 37°C in distilled water.

Microleakage testing

Specimens were thermocycled 10,000 times with a dwell time of 60 s (5°C, 35°C, 55°C and 35°C for 5,25,5, and 25 s, respectively) [8,22]. The samples were then immersed in a 50% silver nitrate solutions for 2 hours, washed, and then immersed in a photographic developer (D-76; Kodak Co, Rochester, NY, USA) for 8 hours under fluorescent light, and abundantly washed under running water. The specimens were sectioned bucco-lingually, parallel to the long axis to obtain 5 pieces. Only the middle 3 pieces with 6 surfaces of measurement per tooth were observed. The restorations were analyzed at occlusal margin (enamel margin) and gingival margin (dentin margin) separately with a stereomicroscope at a 30x magnification (ML9300 MEIJI, JAPAN). The extent of dye penetration was scored according to the following scoring system from previous studies [16,30]. (Table 2 & Figure 2)

Table 2: Dye Penetration scoring system

Score	Extent of dye penetration
0	No dye penetration
1	Dye penetrated between the restoration and the tooth along the restoration-occlusal or restoration-gingival interface up to half the length of the occlusal or gingival wall.
2	Dye penetrated beyond half of the length of the occlusal or gingival wall of the restoration but not reaching the axial wall.
3	Dye penetrated along the entire length of the occlusal or gingival wall and reaching the axial wall.

Figure 2 Microleakage Score

Data collection

The sections of each restoration were scored by the same operator for occlusal margin and gingival margin separately, and the most severe microleakage score was recorded as the score for that restoration. All the specimens were re-evaluated and scored for the second time 24 hours after the first evaluation by the same operator to provide reliability of measurements.

Data analysis

The statistical analysis was done with Mann-Whitney U non-parametric independent analysis to evaluate differences between experimental groups at a significance level of 0.05 using SPSS 20.0 software for Windows (Chicago, IL, USA)

Results

Microleakage scores for the occlusal and gingival walls are presented in table 3. Stereomicroscopic images for the sectioned specimens were illustrated at occlusal wall and cervical wall in figure 3. The Mann-Whitney U test revealed that for gingival margin (dentin margin), group DA showed less microleakage than group NDA and the difference was statistically significant ($P < 0.001$). While at occlusal margin (enamel margin), no significant differences were detected for microleakage score between NDA and DA ($P = 0.247$).

Table 3: Frequency of marginal leakage in occlusal (enamel) and gingival (dentin) margins. N (%)

Group	Groups codes	Occlusal (Enamel) Scores				Gingival (dentin) Scores			
		0	**1**	**2**	**3**	**0**	**1**	**2**	**3**
1	NDA	8	2	0	0	0	0	2	8
		80%	20%	0%	0%	0%	0%	20%	80%
2	DA	5	4	1	0	0	6	4	0
		50%	40%	10%	0%	0%	60%	40%	0%

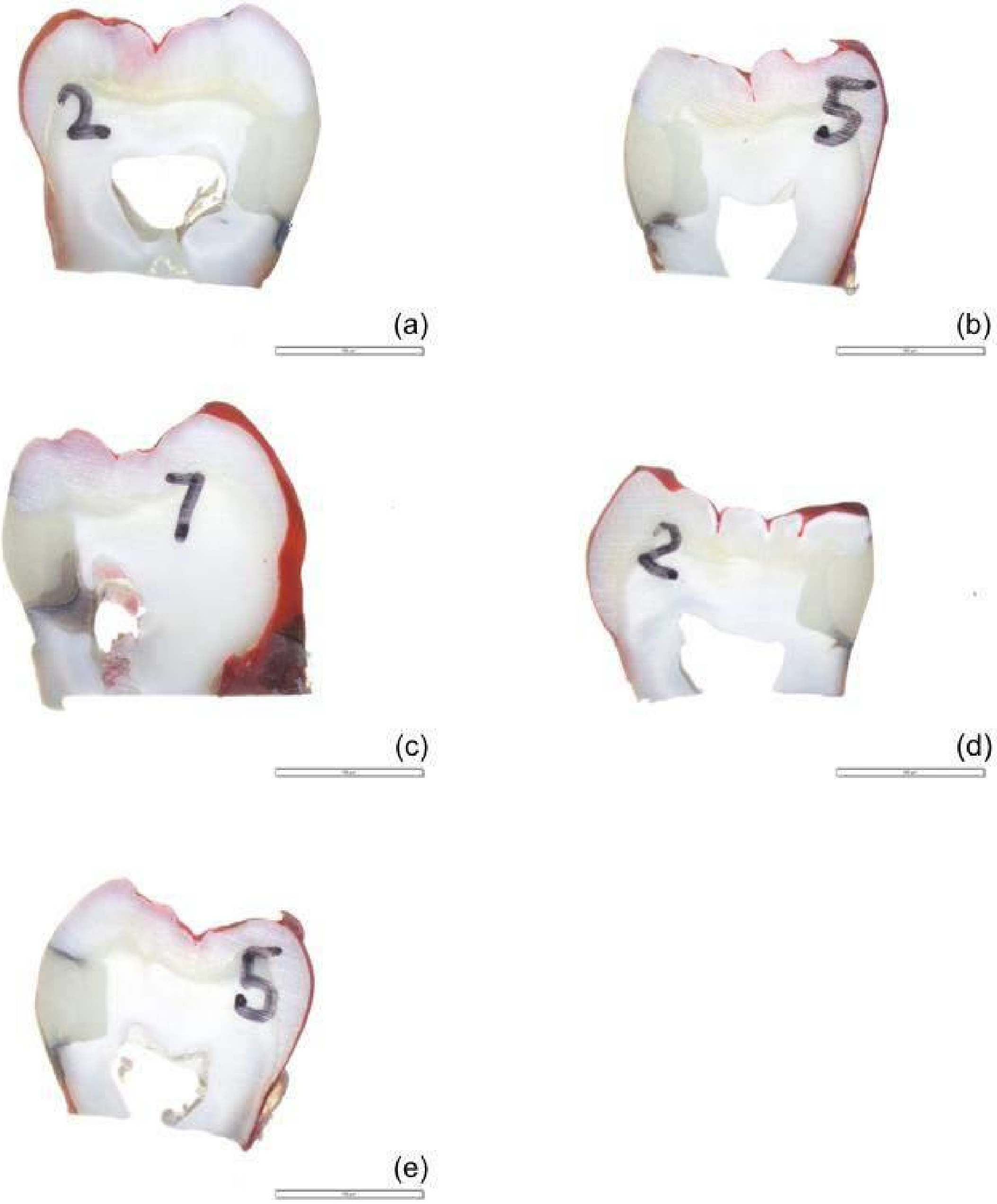


Figure 3: Representative stereomicroscopic images of various leakage scores

a) Stereomicroscopic figure; leakage score 0 at occlusal margin, leakage score 1 at cervical margin

b) Stereomicroscopic figure; leakage score 0 at occlusal margin, leakage score 2 at cervical margin

c) Stereomicroscopic figure; leakage score 0 at occlusal margin, leakage score 3 at cervical margin

d) Stereomicroscopic figure; leakage score 1 at occlusal margin, leakage score 1 at cervical margin

e) Stereomicroscopic figure; leakage score 2 at occlusal margin, leakage score 1 at cervical margin

Conclusion and Discussion

In this study, a microleakage testing using silver nitrate staining was performed in high C-factor resin composite restoration with and without surface pretreatment using a dentin conditioner prior to placement of resin modified glass ionomer base after thermocycling for 10,000 cycles. It was found that at dentin margin, the use of dentin conditioner prior to application of RMGI base in this study gave better result in microleakage test than without dentin conditioner with statistical significances. Therefore, the hypothesis of this study, which stated that the use of dentin conditioner prior to placement of resin modified glass ionomer, as a base or intermediate layer, has no effect in improving marginal integrity of a high C-factor resin composite restoration, is rejected. RMGI show improved working characteristics and adhesion to dentin [11,12]. The chemical reaction allows bonding to dental hard tissues to be established when carboxylic components of the cement and calcium present in enamel and dentin substrates react [31]. In addition to formation of ionic bonding, RMGI presented micro-mechanical interlocking with the conditioned dentin [29]. The aim of conditioning dentin is to remove smear layer which is normally formed during cavity preparation with little or no attack the underlying sound dentin. It also opens the dentinal tubules and partially demineralizes the upper layer of the tooth, leading to an increase of surface area and exposure of micro-porosities, which allow micro-mechanical attachment and also hybrid layer formation which could result in better marginal adaptation [17,29]. This result is in accordance with previous studies which stated that pretreatment of the dentin surface by dentin conditioner has been shown to be effective in improving bond strength especially with RMGI [10,17].

For enamel margin, we found no statistic significant differences of microleakage score between the two experimental groups. The reason behind this could be resulted from pattern of the base used in this study. RMGI base was applied to cover all dentin surfaces of the cavity meaning that, in both groups, the occlusal carvosurface was bonded directly to the composite in the same manner. While at the dentin margin, the seal relied solely on adhesion of RMGI to the tooth structure.

The limitations of this study are that the restorative materials when tested in vitro failed to simulate the dynamic intra oral thermal changes induced by routine eating and drinking. Thermocycling is used in most in vitro studies to simulate stresses when restorative materials have been placed in dental cavity. However, the absence of dentinal fluid flow and the completely altered dentinal surface due to extraction of the specimens made it hard to relate the results with clinical conditions [2,19]. Therefore, it can only provide some initial information for the comparison of different restorative materials [2].

The silver nitrate dye method of measuring microleakage is an acceptable technique, however, it is a very severe test because the silver ion is extremely small (with a dimension of 0.059 nm) when compared to the size of a typical bacterium (0.5–1.0 μm) and thus is more penetrative. It could be assumed that any materials or methods of restoration that prevented leakage of silver ions also prevented leakage of the bacteria [1]. Although the results obtained from this study may not be directly described clinical situation, they can only provide some information regarding the performance of the restorative techniques evaluated. Further clinical study with long term follow-up is still needed. Based on our study we recommend clinician to apply dentin conditioner prior to placement of resin modified glass ionomer as a base when restoring with direct composite in dental cavity which included dentin margin.

In conclusion, based on our findings, the use of dentin conditioner prior to placement of resin modified glass ionomer, as a base or intermediate layer, improved marginal integrity of a high C-factor resin composite restoration.

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