Original Article

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The effect of curing methods for dental adhesive on microleakage and marginal adaptation of porcelain laminate veneer

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Objective: To compare microleakage and marginal adaptation between precured and non-precured methods of two luting cements on IPS e.max® Press laminate veneer.
Materials and Methods: Thirty-six maxillary central incisors were prepared and IPS e.max® Press HT laminate veneers were fabricated by pressable ceramic system. All laminate veneer specimens were randomly divided into two groups for cementation according to two different luting cements: Rely-x® (Rx) and Vitique® (V). In each resin cement group, half of laminate veneers was cemented by using precure (PC) of dental adhesive and another half was cemented by using non-precure (NPC) of dental adhesive. Therefore, four experimental groups were created: Rx-PC, Rx-NPC, V-PC and V-NPC (N=9 in each group). After cementation, all specimens were subjected to thermocycling (500 cycles in water) before immersion in 2% methylene blue for 24 h. All bonded teeth specimens were sectioned into three halves in labio-palatal direction. The microleakage and marginal adaptation were measured at the incisal and cervical margins. The data were statistically analyzed using T-test and Mann-Whitney test at a significance level of 0.05.
Results: There is no statistically significant difference of marginal gap and microleakage between precure and non-precure groups at cervical and incisal margins regardless of both resin cements (P>0.05).
Conclusion: Precure and non-precure methods on total etch dental adhesive system did not affect marginal adaptation and microleakage of IPS e.max® Press laminate veneer.

Keywords: curing methods, dental adhesive, marginal adaptation, microleakage, porcelain laminate veneer, Resin cements

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Introduction

Porcelain laminate veneer has recently become a restoration of choice to improve esthetic of anterior teeth because it requires minimal preparation in case of esthetic concern such as misaligned, diastema, and discolored teeth. Many studies showed porcelain laminate veneer had the most esthetic appearance, while having more adequate strength than the direct composite veneer [1,2]. The use of porcelain laminate veneer restoration in dentistry becomes common due to the development of adhesive system for indirect restoration to achieve esthetic and adequate bonding strength. The success rate of porcelain laminate veneer depends on several factors such as tooth structure, preparation depth, materials, and thickness of porcelain laminate veneer. Moreover, strength and durability of adhesive complex, which established a chemical bond

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between porcelain laminate veneer and tooth structure, are important factors to increase success rate of restoration [1].

Marginal adaptation of porcelain laminate veneer, which is defined as the vertical discrepancy between the finish line of the prepared tooth and the margins of the porcelain laminate veneer, plays an important role for the long-term success rate [2]. Adaptation between the margin of the porcelain laminate veneer and the tooth structure prevents the adhesive resin cement exposed to the oral cavity. In addition, previous study demonstrated that wear of resin cement was found much more in case of larger marginal gap [3]. Therefore, it is desirable to minimize this gap.

When porcelain laminate veneer is bonded to tooth with resin cement, two bonded interfaces are produced. One is the porcelain-resin cement interface and the other is the tooth-resin interface. Microleakage occurred more often at the tooth-resin interface [4,5]. Sorensen *et al* found that microleakage has range from 200 to 1200 microns in 40% of the tooth-resin interface and from 200 to 1100 microns in 20% of the porcelain-composite resin interface [6]. In addition, microleakage was found even more when margins were prepared on dentin compared to on enamel.

Currently, the available resin cements used for ceramic veneers are total-etch adhesive system and light-cured setting. The main advantages of these cements are color stability and longer working time, compared to self-cured and dual-cured resin cements [1]. Nevertheless, it is important that there is enough light transmittance throughout the porcelain laminate veneer to polymerize the light cured luting cement. Several factors can affect the polymerization of light cured luting cements such as ceramic, the curing light source, the luting resin cement material, as well as the bonding substrates. Nowadays, the technique of cementation of porcelain laminate veneer recommended by most manufactures is to apply dental adhesive to prepared tooth without light curing (non-precure) before the cement insertion in order to avoid the film thickness of its adhesive. However, no precured dental adhesive may cause insufficient polymerization resulting in lower bond strength and marginal leakage. However, the disadvantage of precured technique was that such high thickness of the polymerized adhesive in precured step could prevent complete seating of the restoration [5,7].

The objective of this study was to evaluate the effect of different application techniques (precure and non –precure) of dentin adhesive systems on marginal adaptation and microleakage of porcelain laminate veneer. The null hypothesis was that light curing of the adhesives prior to insertion of the porcelain laminate veneer has no effect on marginal adaptation and microleakage.

Materials and Methods

Teeth preparation

Thirty-six human maxillary central incisors were collected, cleaned, and stored in distilled water at room temperature. The teeth were selected base on sound tooth structure and absence of cracks or any defects. All teeth were embedded in autopolymerizing acrylic resin block (DENTSPLY Caulk, Milford, DE, USA) with size 10x20x25 mm (Figure 1). All teeth were prepared for IPS e.max® Press HT laminate veneer (Ivoclar Vivadent, Schaan, Liechtenstein). The incisal and labial surfaces were reduced to 1 and 0.6 mm, respectively. The tooth finish line was chamfer except at the incisal margin finish line was butt joint. The tooth preparation was performed using depth orientation grooves by a diamond bur and followed the IPS e.max Press preparation guideline. One set of diamond burs was used for five teeth and then replaced with a new set.

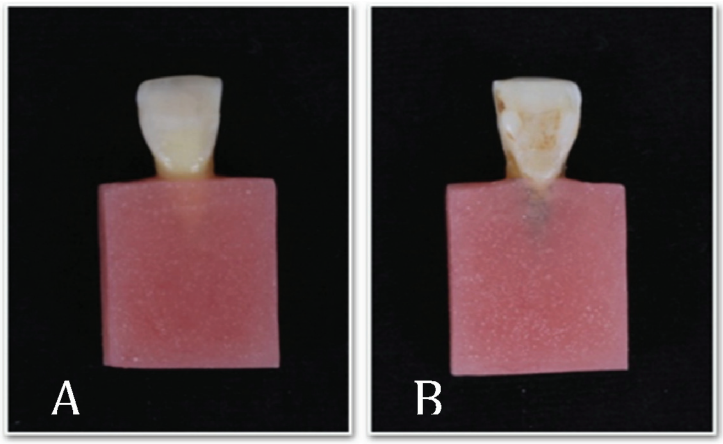

Figure 1 Maxillary central incisor was embedded in auto polymerizing acrylic resin block. (A) Buccal aspect and (B) Palatal aspect.

Porcelain laminate veneer fabrication

After preparation, the teeth were sent to dental laboratory for porcelain laminate veneer fabrication. All prepared teeth were scanned and designed by using laboratory CAD/CAM device. The thickness of porcelain laminate veneers was 0.6 mm at buccal, 1.0 mm at incisal edge. Cement space was set at 20 microns. Wax pattern for each individual tooth was milled to control the thickness. Then, IPS e.max ® Press HT shade A1 laminate veneers were fabricated according to the manufacturer's instruction.

Before cementation, marginal adaptation between tooth and porcelain laminate veneer was measured. Mesial, mid-buccal, and distal points of both cervical and incisal margins were assessed by using optical light microscope at magnification x250 (Nikon eclipse E400 POL, Japan) (Figure 2). Image analysis software (Image- Pro® Plus program, Version 7.0 for Window, Media cybernetics Inc, Rockville, MD, USA) was used to analyze the marginal adaptation by determining a lowest point of porcelain margin to a point of tooth finish line. The specimens having marginal adaptation mean value more than 80 microns were excluded from the experiment.

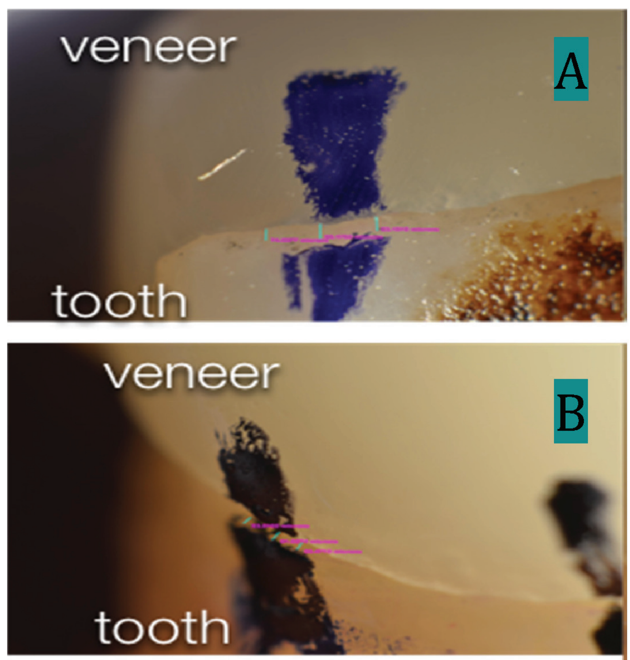

Figure 2 Marginal adaptation at (A) incisal margin and (B) cervical margin with optical light microscope at magnification x250

The porcelain laminate veneers were tried-in and cleaned with ultrasonic cleaner. All laminate veneer specimens were randomly divided into two groups for total etched cementation technique according to two different luting cements as Rely-x® (Rx) veneer cement (3M ESPE, Seefeld, Germany) and Vitique® (V) esthetic resin cement

(DMG America, Ridgefield Park, NJ, USA). In each resin cement group, half of laminate veneers was cemented by using precure (PC) of its dental adhesive and another half was cemented by using non-precure (NPC) of its dental adhesive. According to manufacturer's instruction, each cement was used with its adhesive as shown in Table 1. All treatment applications and materials used for each group are summarized in Figure 3. Therefore, four experimental groups were created: Rx-PC, Rx-NPC, V-PC and V-NPC (N=9 in each group).

Table 1 luting cements and their adhesives used in this study

Cements	
Rely-x® veneer cement (Rx)	Scotchbond™ universal etchant Scotchbond™ universal adhesive
Vitique® esthetic resin cement (V)	DMG Etching Gel Vitique Silane TECO bonding

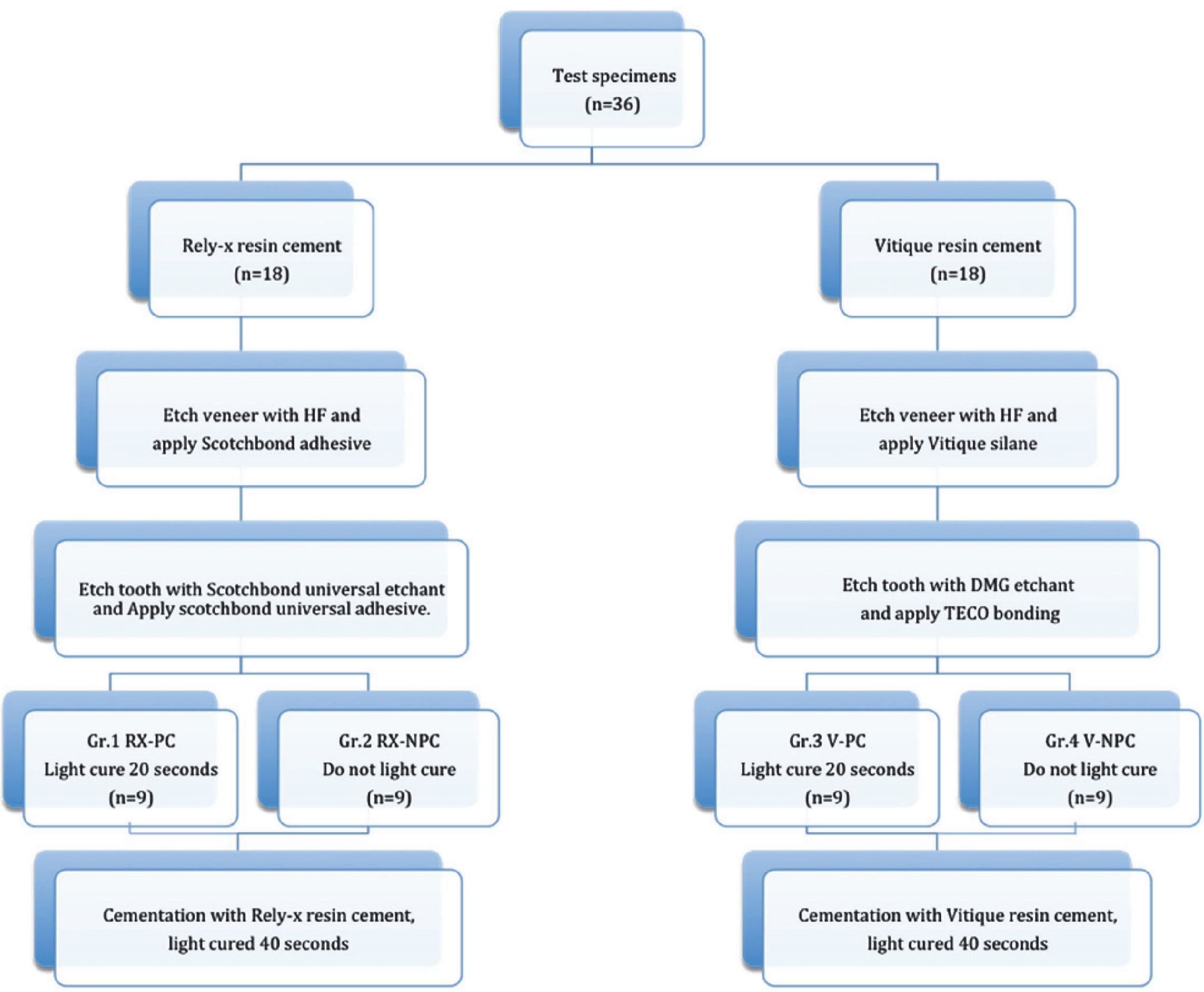

Figure 3 Schematic diagram of cementation for each experimental group.

After cementation, the teeth were stored in 37°C distilled water for 24 hours and set in thermocycling between 5°C and 55 °C for 500 cycles with a dwell time of 25 seconds at each temperature and transfer time 5 seconds.

All tooth surfaces except 1 mm around the porcelain laminate veneer margin were completely sealed with nail vanish for preventing dye penetration through the dentinal tubules before immersion into 2% methylene blue for 24 hours at 37°C. Then, all specimen teeth were sectioned along incisogingival line at the mesial and distal point of cervical margin by low speed cutting instrument (Isomet, BUEHLER, Illinois, USA) under the water-cooling (Figure 4).

Microleakage and marginal adaptation were measured and analyzed in each sectioned side of both incisal and cervical margins by using the optical light microscope at magnification x250 and the Image- Pro® Plus program Version 7.0 for Window.

Marginal adaptation measurement

According to Sorensen *et al* [6], the vertical marginal adaptation was determined by the distance between the finish line of the prepared tooth and the margin of the porcelain laminate veneer (Figure 5).

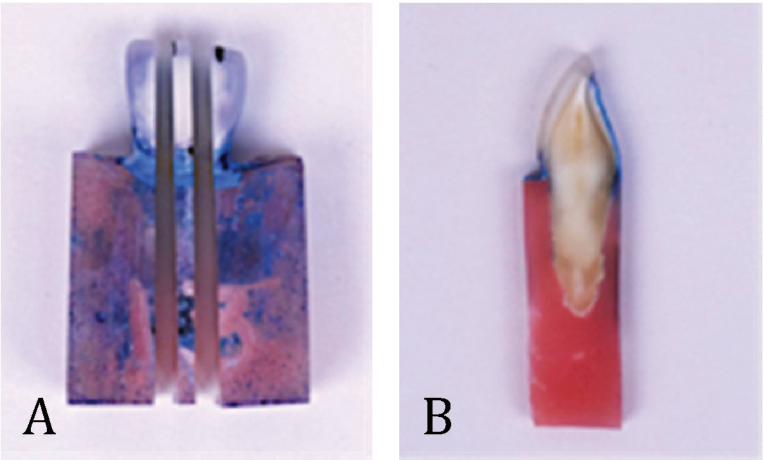

Figure 4 (A) Bonded specimen was sectioned into three pieces. (B) Longitudinal section view of a bonded specimen.

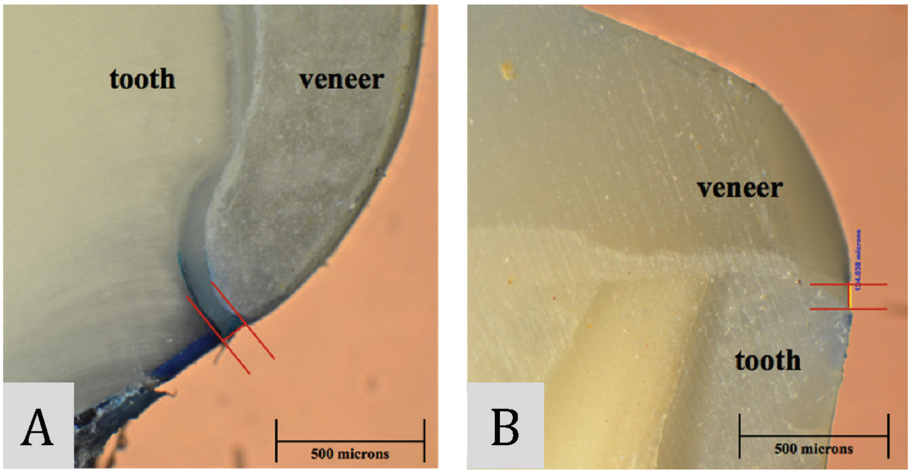

Figure 5 Marginal adaptation at magnification x250 (A) at cervical margin, (B) at incisal margin

Microleakage measurement

The distances of dye that penetrated in two tooth-resin composite interfaces at incisal and cervical margins were measured to determine the microleakage Figure 6. shows the example of a typical margin with microleakage and microleakage measurement.

Statistical analysis

All statistical computations were performed by SPSS software (IBM corp. released 2013, IBM SPSS statistics for Windows, version 22.0; Armonk, NY: IBM corp.). The significant level was set at $p=0.05$. Shapiro-Wilk test was performed to validate normality of the data and Levene's test for equality of variances between group data. Comparison in the marginal adaptation and microleakage between different curing methods were analyzed by independent t-test and nonparametric Mann-Whitney U test, respectively.

Results

Marginal adaptation analysis

Means of marginal gap at cervical and incisal margins of both resin cements (Rx and V) in different curing methods of dental adhesive (PC, NPC) are presented (Figure 7). According to Rely-x® cement group, marginal gaps at incisal margin were higher than the gaps at cervical margin in both NPC and PC groups. While in Vitique® cement group, marginal gap at incisal was higher than cervical marginal in only PC group. However, in both resin cements, there is no statistically significant difference of marginal gap between precure and non-precure groups at cervical and incisal margins (P>0.05).

Microleakage analysis

Microleakage values at tooth-resin cement interfaces at cervical and incisal margins of both resin cements were showed in figure 8 and 9, respectively. Median microleakage values of precure groups of both Rely-x® and Vitique® resin cements were less than that of the non-precure group except Rx-PC group at incisal margin. However, the Mann-Whitney U test showed no statically significant difference of microleakage in different curing methods of dental adhesive (precure and non-precure) at tooth-resin cement interface either in cervical or incisal margin of both resin cements (p>0.05).

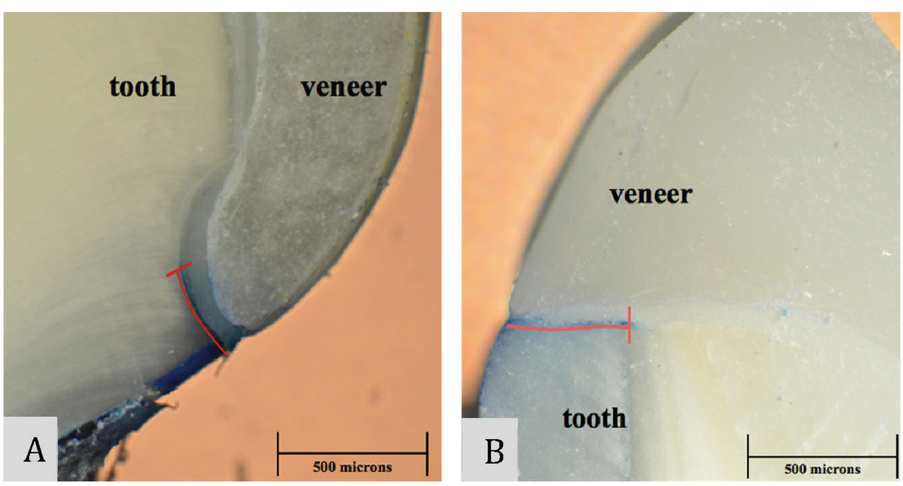

Figure 6 Example of microleakage at tooth-resin composite interface (A) cervical margin and (B) incisal margin (at magnification x250).

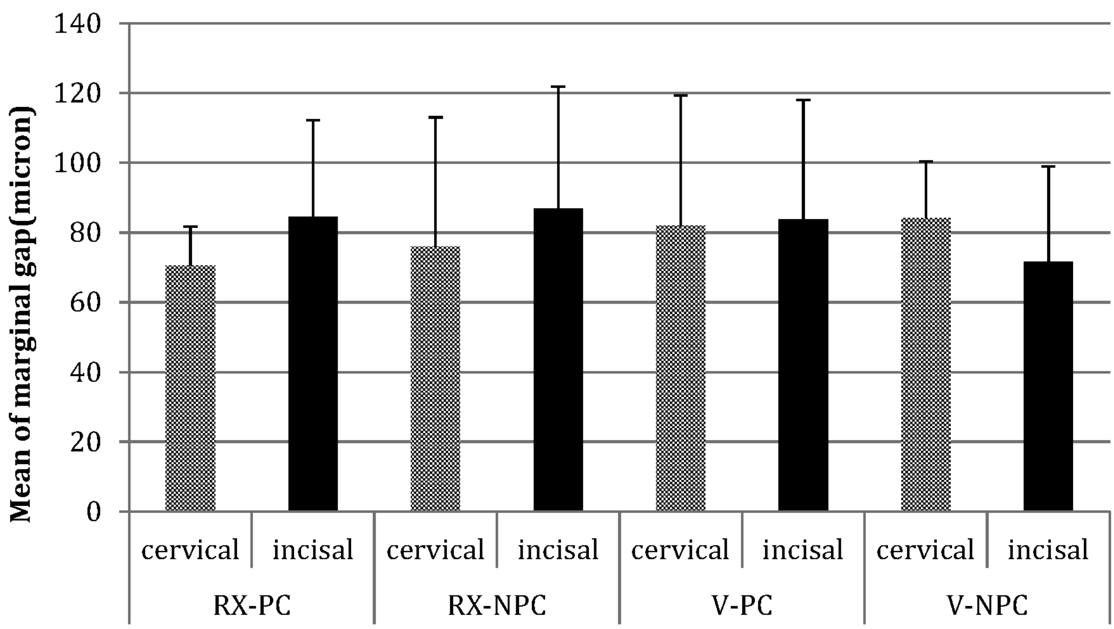

Figure 7 The mean ± SD values of marginal gap at cervical and incisal margins of both resin cements in different curing methods of dental adhesives.

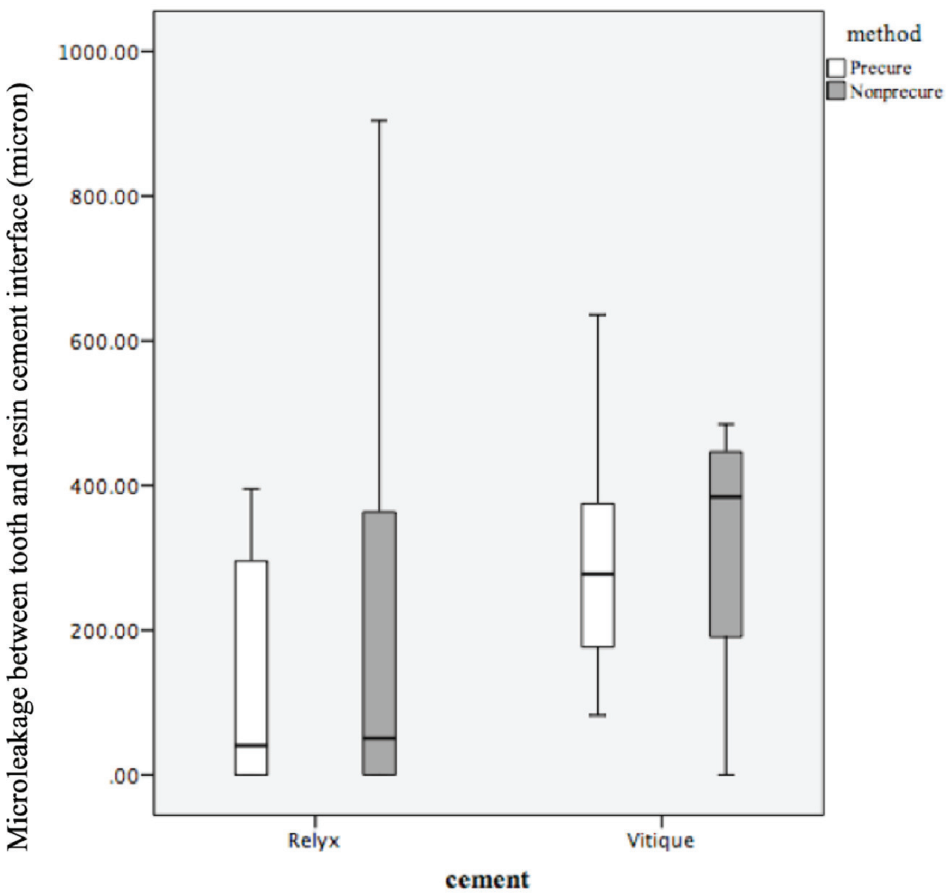

Figure 8 Microleakage between tooth and resin composite interface at cervical margin.

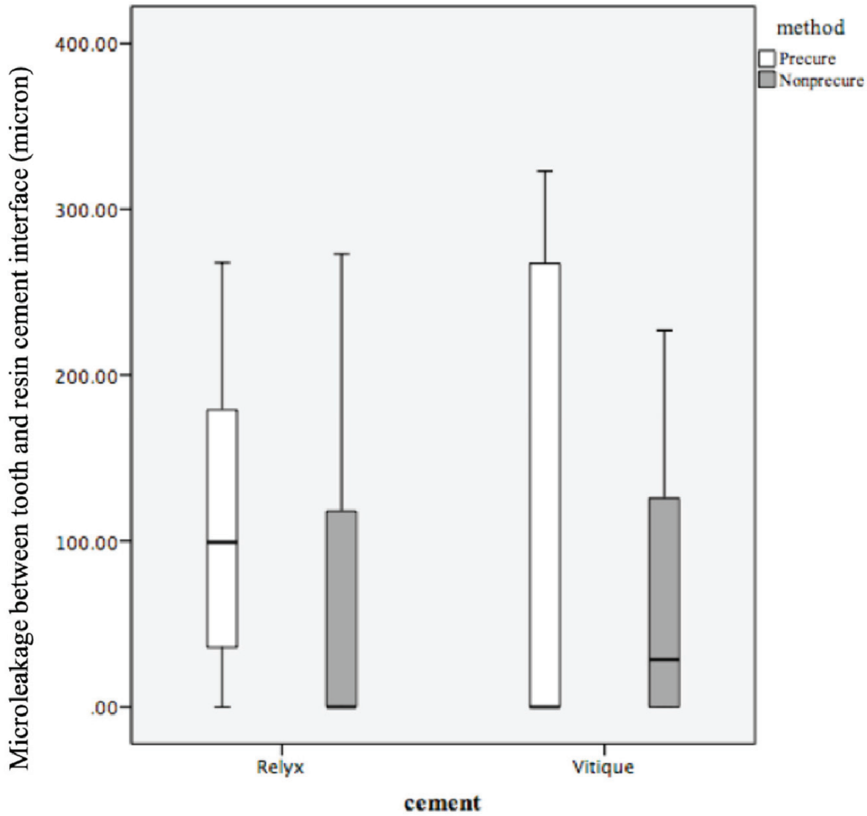

Figure 9 Microleakage between tooth and resin composite interface at incisal margin.

Discussion

The polymerization shrinkage of the luting resin cement and the different in thermal expansion coefficient among cement, tooth, and porcelain can cause stress at tooth-cement and cement-porcelain interfaces. Due to this contraction stress, there is a competition between the adhesive forces of the two bonded interfaces. The interface with the lower adhesive forces will fail and microleakage will occur at this interface leading to staining, post-operative sensitivity, and recurrent caries [8]. Therefore, the interface between porcelain laminate veneer and tooth structure is an area of clinical concern especially interface between resin cement and tooth structure. The minimal marginal gap and microleakage of restorations are necessary since increasing marginal gap results in increasing cement dissolution, which reduces the success rate of restoration. Several techniques have been used to test the microleakage such as use of bacteria, compressed air, chemical or radioactive tracer, electrochemical investigation, scanning electron microscope, and dye penetration [5-7]. In this study, the dye penetration method was selected to investigate the internal seal of luting cements since this method is common and cost effectiveness.

Many recent studies concerned about reducing microleakage and improving marginal adaptation of indirect restoration [7,9,10]. The different materials and techniques in dental adhesive of veneer restoration have significant effects on marginal adaptation of the final restoration. The improvement of dental adhesive systems such as the modified cementation technique was discovered to achieve the esthetic appearance and adequate strength. Previous studies showed the influence of dentin adhesive application technique (precure vs non-precure) on marginal adaptation and microleakage of indirect restorations. Precure technique of dental adhesive decreased levels of microleakage but increased luting space or gap [9-11]. The precure method was expected to have smaller microleakage than non-precure group because of the complete polymerization of dental adhesive between tooth and resin cements. On the other hand, marginal gap of precure group may be larger than non-precure group due to the thickness of the polymerized adhesive.

Conversely, our result showed no statistical difference in marginal adaptation between two different curing methods. In this study we used natural human teeth and fabricated the porcelain laminate veneers individually in order to represent clinical situation. Only, one resident student in prosthodontic program had done all clinical steps including marginal gap and microleakage measurement to reduce the error. However, all porcelain laminate veneers were fabricated by one commercial lab in Bangkok, Thailand. According to this study, maxillary central incisors and lithium disilicate veneer (IPS e.max Press) were selected. Among ceramic systems, lithium disilicate has gained popularity for anterior restorations because of its physical properties [12]. All specimens in this study were fabricated by pressable ceramic system, while the wax patterns were milled with CAD/CAM system to control the thickness of porcelain laminate veneer as 0.6 mm. Moreover, the marginal gap before experimentation of all tested specimens were investigated to be less than 80 microns. The ranges of marginal adaptation in all groups of this study were about 70-80 microns. Several studies agree that marginal adaptation values of indirect restorations should be between 100 and 120 microns to avoid wear of cement [13,14]. Thus, the marginal adaptation values of both techniques in this study were clinically acceptable. According to manufacturer's information, the film thickness of Rely-x® resin cement is only 10 microns and Scotchbond Universal adhesive interface with dentin in total-etched mode is in the range of 5 –10 microns. The film thickness of Vitique® resin cements is only 16 microns. Similarly, Coelho *et al*. reported the mean of all precure adhesive film thickness ranged from 5.7 to 14.8 microns [11]. Whilst no adhesive film could be distinguished from the resin-luting layer in adhesives used without precure. Therefore, the low film thickness of both resin cements and adhesives may have no effect on marginal adaptation between two different techniques (precure and non-precure).

Regarding microleakage evaluation, no statistically significant difference was found between non-precure and precure groups in both resin cement. According to previous study, complete polymerization could protect microleakage between tooth-resin interface [7]. The degree of polymerization of the resin cement would be analyzed. Polymerize mechanism of resin cements occurs when the presence of a light source to activate photo initiators to start the polymerization reaction [15]. The thickness of porcelain veneer is the primary factor determining the light transmittance. The color and opacity of porcelain would also affect the amount of light absorption. Scotti *et al* reported that lithium disilicate veneer with a thickness between 0.6 and 1.5 mm has no effect on degree of conversion of light cured resin cement and has sufficient polymerization level [16]. Corresponding to another study, Runnacles *et al* reported that the degree of conversion of light cured resin cement depends on the thickness and type of ceramics when veneers are thicker than 1.5 mm [17].

Although, this study selected natural human teeth and porcelain laminate veneer to represent clinical use but it was performed in laboratory condition so it may need longer thermocycling time before investigation. In addition, tooth-cement bond strength would be another aspect to find the proper technique. In conclusion, precure and non-precure methods did not affect the marginal adaptation and microleakage of IPS e.max® Press laminate veneer cemented with two luting cements.

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Competing interests: None declared
Ethical approval: The ethical approval for this study was obtained from the Committee on the Ethics of Research on Human beings of Mahidol University, Bangkok, Thailand (certificate of approval number MU-DT/PY-IRB 2018/041.0910)

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