Original Article

Effect of Different Placement Techniques on Microleakage of Class V Composite Restorations

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Abstract:

Objective: Various techniques of composite placement have been used to decrease microleakage around the composite restorations. Due to controversial results, the present study was conducted to investigate the effect of different placement techniques on microleakage in class V composite restorations.

Materials and Methods: Sixty class V cavities were prepared on the buccal and lingual surfaces of 30 extracted healthy human premolars. The teeth were randomly assigned to five groups, and were restored with composite resin, using five different techniques: (1) horizontal increments (gingivo-occlusal), (2) horizontal increments (occluso-gingival), (3) oblique increments (gingivo-occlusal), (4) oblique increments (occluso-gingival), and (5) bulk placement. After thermocycling, 500 cycles of between 5°C and 55°C (SD=2), and immersion in 0.5% alcoholic Fuschin, the teeth were then sectioned and evaluated for microleakage by stereomicroscope (×16). Microleakage was scored on a 0-4 scale. Non-parametric Mann-Whitney U and Kruskal-Wallis tests served for statistical analysis.

Results: Gingival margins of class V cavities showed microleakage regardless of the placement technique. Oblique (gingivo-occlusal) technique showed less microleakage in gingival margins of the restorations compared to bulk technique. The least microleakage in gingival margins was related to group 3 while the most microleakage was related to group 5. Bulk and oblique (gingivo-occlusal) incremental techniques produced significantly different rate of microleakage ($P<0.003$). Group 3 showed the most difference with groups 5, 1, 2, and 4, respectively.

Conclusion: Among four incremental techniques, the gingivo-occlusal oblique filling technique resulted in a lower leakage value, when compared to the bulk filling technique.

Key Words: Dental Leakage; Composite Resins; Dental Cavity Preparation

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INTRODUCTION

Dental caries is known to be the most prevalent chronic disease in the world [1]. Improvements in health care and health knowledge have extended human's life spans. Moreover, due to attention to oral health, edentulism has decreased and more teeth are preserved for longer period. Consequently, an increase has occurred in the prevalence of tooth cervical lesions (both carious and non-carious: abrasion, erosion, abfraction) needing class V restoration [2]. In such restorations, absence of enamel or presence of a very thin layer of enamel at gingival margin may make the bonding process more difficult in these areas and as a result, may increase microleakage. In addition, because of abfraction and debonding of restoration at this area, a proper and accu-

rate method of restoration is needed.

For the past several years, different techniques and materials have been examined to reduce microleakage in class V restorations [3-8]. Strength and longevity of these restorations can be potentially improved with advances in esthetic restorative materials and also introduction of latest generation of bonding agents [9]. Efficient bonding of restorative materials to cavity walls will produce well-sealed and long lasting restorations.

Bonding to enamel is a relatively simple process, without major clinical requirements or difficulties due to its structural integrity and absence of fluid, but bonding to dentin has proved to be more problematic than enamel because of structural heterogeneity and presence of fluid in its structure [10-13]. Studies have shown that proper seal of dentin plays an important role in preserving pulpal health [14]. To achieve this goal, different materials such as liners, cement bases, oxalates and bonding agents have been investigated [15].

Microfilled composite resins are supposed to obtain better marginal performance in non stress-bearing areas [16]. These kinds of composites have a lower Young's modulus and high elasticity which enable them to relieve some of the polymerization contraction stress by flow relaxation; thereby, they are the material of choice for cervical class V restorations [16,17].

A major disadvantage of visible light cured composite is polymerization contraction that results in gap formation, particularly at dentin interface [18-20]. This phenomenon leads to ingress of bacteria, toxins, fluids, molecules, or ions between the cavity walls and the restorative materials. Microleakage at marginal area leads to post operative sensitivity, marginal staining, recurrent caries, and development of pulpal pathology, and this is the main problem of composite restorations [21-23].

Incremental placement of light cured composite resin has been suggested to reduce polymerization shrinkage and also improve marginal adaptation [24]. However, at present, there is no technique or material that can provide complete marginal adaptation, and in spite of significant advances in dentin bonding technology, a complete prevention of microleakage specially at dentin or cemental margins of cavity has not yet been achieved [4,9,17-23].

The aim of the present study was to compare the effect of five placement techniques on microleakage of class V composite restorations.

MATERIALS AND METHODS

This experimental study was done on 30 intact human premolars extracted for orthodontics reasons with no crack, decay, fracture, abrasion, previous restorations, or structural deformities, which all were stored in normal saline before the study. They were cleaned with ultrasonic scaler one week prior to examinations and cleaned with pumice and rubber cup. Then, all the teeth were disinfected with 0.5 % Chloramine for 24 hours and stored in distilled water at room temperature. Using 008-diamond bur (Diatech Dental AG), cavities with 3 mm occluso-gingival height, 3 mm mesio-distal length and 2 mm cavity depth were prepared on the buccal and lingual (palatal) surfaces of teeth with air/water spray. A digital caliper was used to measure cavities dimension. The burs were changed after every five preparations. All the preparations were performed with the gingival margin placed near CEJ. They were assigned into five groups including (1) horizontal increments (gingivo-occlusal), (2) horizontal increments (occluso-gingival), (3) oblique increments (gingivo-occlusal), (4) oblique increments (occluso-gingival), and (5) bulk placement. All groups contained six teeth (12 cavities) with equal maxillary and mandibular teeth. The materials used for cavity restoration are shown in Table 1.

After the teeth were restored, they were polished with polishing burs (Diatech Dental AG)

and Sof-Lex discs (3M Dental Products). Discs were replaced after every 10 polishings. The samples were stored in distilled water for 24 hours and then thermocycled for 500 cycles between 5°C (SD=2) and 55°C (SD=2) temperature. The radicular apices of all teeth were sealed using composite and all the teeth were covered with nail varnish except for 1-2 mm around the margins of the restorations to limit dye penetration to cavity margins. After restoring in alcoholic Fuschin 0.5% for 24 hours, the samples were washed and placed into crystalline acrylic resin. They were sectioned longitudinally from the middle of cavity (buccolingually) into two mesial and distal parts and each part was observed under stereomicroscopic with ×16 magnification (Olympus Optical, Model SZX-ILLB200) and using digital camera (JVC TK-C1380) to evaluate microleakage. The grade of microleakage was as follows: 0–No microleakage, I–microleakage less than half of the cavity in occlusal and gingival floor, II–microleakage more than half of the cavity in occlusal and gingival floor, III–microleakage in axial wall, IV–microleakage from axial wall to pulp.

Non-parametric Mann-Whitney U and Kruskal-Wallis tests served for statistical analysis.

RESULTS

Fig 1 and 2 show the microleakage found in occlusal and gingival margins of five study groups were as follows:

At occlusal surfaces, 16.7% and 3.3% of teeth in horizontal (gingivo-occlusal) technique, 10% and 5% in horizontal (occluso-gingival), oblique increments (gingivo-occlusal) and bulk techniques, and 18.3% and 1.7% in oblique technique (occluso-gingival) showed microleakage of 0 and I grades respectively.

In gingival surfaces, when the horizontal placement technique (gingivo-occlusal) was used, the microleakage grades were as follows: grade 0: 0%, grade I: 1.7%, grade II: 3.3%, grade III: 11.7%, and grade IV: 3.3%. In the other horizontal technique (occluso-gingival), the observed rates were 1.7%, 0%, 3.3%, 15% and 0%, respectively for grades 0, I, II, III and IV. In oblique technique (gingivo-occlusal) the corresponding figures were 1.7%, 3.3%, 6.7%, 8.3% and 0%, respectively. In the other oblique increments (occluso-gingival), no cases exhibited grade 0 and I while 6.7%, 11.7%, and 1.7% exhibited grades II, III and IV microleakage. In bulk placement technique, no cases showed grade 0, I and II whereas 15% and 5% of samples exhibited grades III and IV microleakage, respectively.

The statistical analysis through Kruskal-Wallis test showed no significant differences in microleakage at occlusal margins among groups ($P>0.8$). However, significant statistical difference existed on microleakage at gingival margins among the groups ($P<0.01$). The results of Mann-Whitney U test showed that bulk and oblique (gingivo-occlusal) incremental techniques produced significantly different rate of microleakage ($P<0.003$).

Oblique technique (gingivo-occlusal) technique showed the most significant difference values with bulk technique, then with horizontal incremental (gingivo-occlusal) and finally with horizontal incremental (occluso-gingival) and oblique incremental (occluso-gingival) techniques, respectively.

Table 1. Materials used in the study.

Material	Product type	Manufacturer
Heliomolar	Microfilled composite, Monomeral matrix (22%), UDMA,Bis-GMA, Decandrol DMA	Vivadent Ivoclar
Excite	Dentin bonding agent (HEMA, Dimethacrylate and acrylate acid phosphoric)	Vivadent Ivoclar ,Batch # 16833

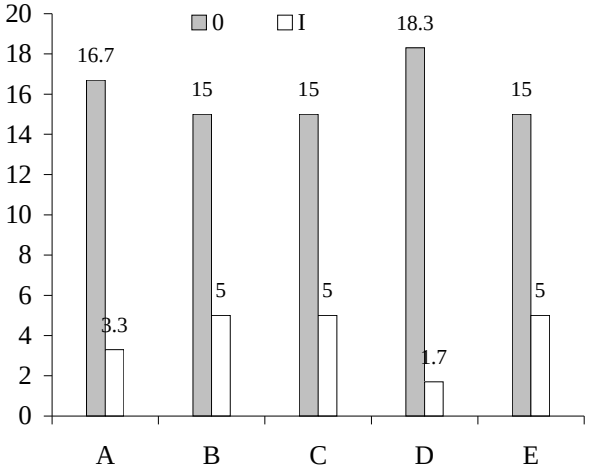

Fig 1. Percentage and grades of microleakage at occlusal surfaces of class V cavities restored with five techniques of composite placement.

Microleakage Grades: 0: no microleakage, I: microleakage less than half of the cavity in occlusal and gingival floor, II: microleakage more than half of the cavity in occlusal and gingival floor.
A. Horizontal increments (gingivo-occlusal)
B. Horizontal increments (occluso-gingival)
C. Oblique increments (gingivo-occlusal)
D. Oblique increments (occluso-gingival)
E. Bulk placement technique

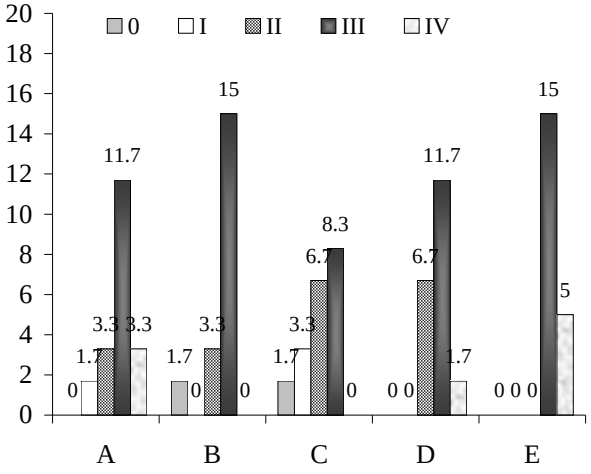

Fig 2. Percentage and grades of microleakage grades at gingival surfaces of class V cavities restored with five techniques of composite placement**.**

Microleakage Grades: 0: no microleakage, I: microleakage less than half of the cavity in occlusal and gingival floor, II: microleakage more than half of the cavity in occlusal and gingival floor, III: microleakage in axial wall, IV: microleakage from axial wall to pulp.
A. Horizontal increments (gingivo-occlusal)
B. Horizontal increments (occluso-gingival)
C. Oblique increments (gingivo-occlusal)
D. Oblique increments (occluso-gingival)
E. Bulk placement technique

DISCUSSION

The present study compared the effect of five placement techniques on microleakage of class V composite restorations. The results showed that regardless of the technique used, microleakage was observed at gingival margins. The least microleakage values were observed in oblique incremental (gingivo-occlusal), and the most values in bulk techniques.

Different composite placement techniques have been recommended (bulk technique and incremental technique). Bulk placement technique may be indicated in deep cavities. In this technique high internal stresses may be generated in the material and loss of marginal integrity can occur, as the larger the volume of composite to be polymerized, the more will be the polymerization shrinkage [25].

The incremental technique is based on polymerizing with resin-based composite layers less than 2 mm thick. This technique can help obtaining good marginal quality and preventing distortion of the cavity wall (thus securing adhesion to dentin). With this technique, complete polymerization of the resin-based composite is ensured [26].

In the present study, cavities with smooth margins at CEJ were prepared, as the shape and location of margins of class V cavities can affect the rate of microleakage [27]. The cavity dimension was also determined as previous studies [28-31] and the cavities were restored with composite resin using bulk and incremental technique. Microfilled composite was used due to its structural properties. Since many variables makes it difficult to assess the absolute value of microleakage for a given material, only one type of composite was used as a filling material for all class V restorations (Microfilled, Vivadent) [32].

Several studies reported that thermal changes occurring in the oral cavity are much less than

that obtained from thermocycling techniques. These changes can affect the bonding between tooth and restorative materials [33-35]. Trowbridge [36] also stated that since there is more dwell time during thermocycling compared to oral cavity, this could be the reason for increased microleakage in *in vitro* studies compared to clinical situation. Barnes et al [37] compared microleakage value in *in vitro* models and in clinical situations and reported more leakage in laboratory experiments than in clinical situations [37]. He suggested that 500 thermocycles at 55°C and 5°C to simulate oral cavity conditions [37]. In the present study, the temperature and number of thermal cycling was based on Barnes' et al study [37].

Dye penetration technique was used for evaluation of microleakage as it is a simple, inexpensive, nontoxic, traceable at low concentration, common, and comparable method for evaluating of microleakage [28-45].The grading of microleakage was scored based on previous studies [28,29,33,38].

The results of the present study showed that bulk technique resulted in more polymerization shrinkage and microleakage than incremental technique. The reasons could be increased polymerization contraction stress due to great volume of composite and decreased effectiveness of polymerization at deeper portions of the composite [46]. There was a decrease in microleakage when incremental technique was used for insertion of composite, which could be due to reduced volume of the resin and the stress generated on the cavity walls and also due to more uniform and efficient polymerization of resin composite through its entire thickness [46,47].

Several studies have been performed on composite placement techniques. Krejci and Lutz [39] reported no significant difference between bulk and horizontal (gingivo-occlusal) placement techniques [39], whereas in another investigation horizontal (gingivo-occlusal) increments was suggested to be more appropriate for class V restorations compared to vertical increments [28].

In the present study, cavity configuration or "C" factor (bonded surface/free surface) for each horizontal layer was 2.33, while 1.5 and 9 for vertical and final vertical layers, respectively. It was observed that, the polymerization shrinkage which occurred in final vertical layer resulted in debonding of composite from the tooth surface and increasing microleakage [26,28]. In a study conducted by Aguiar et al [28], no comparison was performed between horizontal increments with oblique and bulk techniques.

According to finite element analysis on class II and class V cavities, bulk and oblique placement techniques showed the least and most stress during polymerization, respectively [30,43].

The two-step horizontal placement technique has been shown to provide superior bonding results as compared to the bulk technique [24]. A number of studies propose application of the oblique technique from the gingival aspect for class V cavity restorations [31,47]. Puckett et al [31], found no significant difference between oblique incremental and bulk techniques, while according to Tjan et al [47] this difference was significant.

Several investigations have also evaluated the occlusal oblique incremental technique [29,48-50]. Leclaire et al [48] demonstrated that amount of microleakage in sandwich technique in which, glass- ionomer and microfilled composite were used together was less than microleakage in application of microfilled resin alone. The effect of other factors like re-bonding of gingival margin and changes in light direction on microleakege, have been studied and significant differences were not observed between the two techniques [29].

The results of present study showed the least amount of microleakage at the occlusal margin. Kruskal-Wallis analysis showed no significant differences on the amount of micro-

leakage at the occlusal margin of five groups. Bond to enamel is a relatively simple process, without major clinical requirements or difficulties. The presence of enamel at the occlusal margin of cavities makes a suitable bonding in this region, as observed in many studies [24,28,38,39,43-55]. Bonding to dentin on the other hand, presents a much greater challenge and has proved to be more problematic than enamel for a number of reasons including presence of water in dentin and many variations in substrate [1].

Different values of microleakage were observed in the gingival region. The oblique incremental (gingivo-occlusal) and bulk techniques presented significantly different microleakage values, while other techniques showed no significant differences.

The results of the present study coincide with previous investigations [29,39,47,48], but do not agree with others [24,30,31,43]. Puckett et al [31] used hybrid composite and bonding systems in bovine samples, which differ from composite and bonding system used in this study. Since the type of composite and bonding system can influence the amount of polymerization shrinkage and resulted microleakage, this could be the reason for differences in the result of present study and other studies.

In addition, in two studies conducted by Winkler et al [30] and Versluis et al [43], the amount of polymerization stress on the cavity walls, but not the extent of microleakage was evaluated; and since microleakage is a multifactorial phenomenon and their study has been performed under different situations, the differences between their results and our results could be explained.

CONCLUSION

From the results of the present study, it can be concluded that:

1- In class V restorations, microleakage was observed at the gingival margins regardless of placement technique.

2- Oblique incremental (gingivo-occlusal) technique showed lesser microleakage than bulk technique at gingival margin.

3- The least microleakage values were observed in oblique incremental (gingivo-occlusal), and the most values in bulk techniques.

4- Oblique technique (gingivo-occlusal) technique showed the most significant difference values with bulk technique, then with horizontal incremental (gingivo-occlusal) and finally with horizontal incremental (occluso-gingival) and oblique incremental (occluso-gingival) techniques, respectively.

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