Original Article

The Effect of Finishing and Polishing Time on Microleakage of Composite Restorations

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Abstract

Background and Aim: Composite resins require time to complete their polymerization. This process usually reaches its maximum rate after 24 hours. On the other hand, immediately after restoration, water sorption results in hygroscopic expansion of composite resins and the mentioned two factors usually reachequilibrium after a week. Considering the effect of mentioned processes on the microleakage of composite restorations, the purpose of the present study was to evaluate the effect of finishing and polishing time on the mean microleakage of composite restorations.

Materials and Methods: In this in-vitro experimental study, 60 sound human premolar teeth were selected. A standard Class V cavity was prepared measuring 1.5 mm in depth, 3 mm in width and 2 mm in length on the buccal surface of each tooth and incrementally restored with composite resin. Next, the teeth were randomly divided into 4 groups. The teeth in groups 1, 2, 3 and 4 were finished and polished immediately, 15 min, 24 h and one week after storage in distilled water at 37°C, respectively. Specimens in each group were subjected to 500 thermal cycles. The teeth were then coated with adhesive wax and nail varnish and immersed in 2% fuchsin solution for 24h. The specimens were washed and each sample was longitudinally sectioned in half by a diamond saw. Both halves were evaluated in terms of dye penetration under a stereomicroscope at 28X magnification. For each sample, the section with greater degree of microleakage was selected. Kruskal Wallis test and Mann Whitney U test were used for data analysis with a 99.1% confidence interval.

Results: The lowest mean microleakage was observed in the occlusal margin of group 3 teeth; while the highest mean microleakage belonged to the occlusal and gingival margins of teeth in group 2. A significant difference was noted between the 4 groups in occlusal margin microleakage ($p<0.009$). However, no such difference was found in gingival margin.

Conclusion: This study showed that the finishing and polishing timewas effective on the mean microleakage in the enamel margin of composite restorations. The best time of finishing and polishing was 24h after the restoration. Time of finishing and polishing had no effect on microleakage in dentin margins of restorations.

Key Words: Composite resins, Polishing, Microleakage

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Introduction

Composite resins are among the most commonly used dental materials. One major drawback of composite resins is their polymerization shrinkage during setting that leads to microleakage [1]. Mi-

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croleakage is defined as the penetration of oral fluids, bacteria, toxins,molecules and soluble ions through the gap between the cavity walls and the restorative material [2]. Proper conduction of finishing and polishing is an important step in restorative dentistry leading to improved esthetics, longevity and survival of restorations; whereas, the residual surface roughness enhances plaque accumulation, gingival inflammation and surface discoloration [3]. Extensive studies have evaluated different conditions and various techniques of finishing and polishing of composite restorations. Some researchers have suggested diamond burs along with water spray for wet finishing and reported the highest degree of microleakage following dry finishing [4]. Whereas, another group noticed that in at least one of the evaluated cases, surface temperature increased to the level of glass melting point due to dry finishing, affected the filler particles and caused significant surface improvement. They suggested that if aluminum oxide discs are used, dry finishing is even superior to wet finishing [5]. The process of finishing and polishing can improve surface hardness as well [6]. Several studies have demonstrated that delayed finishing and polishing with different techniques yields equal or superior surface hardness compared to situations where finishing and polishing are performed immediately after the restoration. In case of conduction of finishing and polishing immediately after the restoration, the composite resin is more susceptible to be affected by the generated heatyieldinglower hardness scores [7]. In another study, it was suggested that finishing with a 24h delay results in better marginal fit [8] and less microleakage was observed in microfilled composite restorations polished with diamond burs under water coolant [9].

Cenci et al, in 2008 evaluated the effect of time and polishing techniques on surface roughness and microleakage of composite resin restorations and found that a combination of composite type, time and polishing technique affects the surface roughness, hardness and microleakage of restorations but overall, immediate polishing produced no detrimental effect compared to delayed finishing [10]. However, another group of investigators evaluated the effect of instrumentation time on microleakage of resin modified glass ionomers and concluded that delayed finishing and polishing leads to less microleakage [11]. In comparison with the above mentioned studies, literature regarding the effect of finishing and polishing time on the microleakage of composite restorations is scarce. About 75% of the polymerization process is completed within 10-15 min after light-curing and polymerization shrinkage is compensated by the process of water sorption and an equilibrium is reached after 7 days for most resins [12]. This study aimed to assess the effect of finishing and polishing time on the microleakage of composite restorations.

Materials and Methods

In this in-vitro experimental study, Class V cavities with 2 mm occlusogingival length, 1.5 mm depth and 3 mm mesiodistal width were prepared with a fissure diamond bur (Original Bur Head Size-Teeskavan, Iran) and a hand piece (NSK, Japan) on the buccal surfaces of 60 sound human premolars that had been collected during 6 months in 2% timol solution. In all cavities, the gingival margin was located 1 mm beneath the CEJ and a new bur was used for every 10 teeth. The teeth were then stored in distilled water and randomly divided into 4 groups of 15. All specimens were restored as follows: first, each tooth was washed and dried with water and air spray, respectively. Clearfil SE bond self-etch adhesive bonding (Kuraray Medical Inc., Japan) was used in this study;which did not require separate etching of the cavity. The primer was first applied by an applicator, allowed 30s and then gently air-dried. The bonding agent was then applied, spread over the cavity surface with gentle air flow and light cured for 20s according to the manufacturer's instructions using QTH light curing unit (Coltolux 2.5 Coltene/Whaledent, USA). A2 shade hybrid composite resin (Filtek Supreme, 3M, ESPE, USA) was applied to the cavity in two increments and each increment was cured for 40s according to the manufacturer's instructions. Fifteen teeth in the first group were polished immediately after restoration using orange Soflex polishing discs (Soflex, 3M ESPE, USA). Each specimen was polished for 10 times with the disc for a total duration of 20s. A new disc was used for each tooth. Specimens in groups 2, 3 and 4 were polished after 15 min, 24h and one week of storage in distilled water at 37°C, respectively. Afterwards, specimens in each group were separately subjected

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to 500 thermal cycles between 5-55°C for 20s at each temperature. Then, two coats of nail varnish were applied to the entire tooth surface in a way that the nail varnish had 1 mm distance from the occlusal and gingival margins. The mesial and distal restoration margins had been covered by the varnish in order not to allow the microleakage in other areas to interfere with the results. Nail varnish was allowed time to dry and then specimens in each group were immersed in 2% basic fuchsin (Basic Fuchsin, Merck, Germany) at room temperature for 24h. After completion of this time period, specimens were rinsed under running water and each tooth was longitudinally sectioned in half in a bucco-lingual direction through the middle of the restoration using a diamond saw (Diamond cutting disc, Gota, Switzerland) and a micromotor (Micromotor, Marathon, Korea). Copious water-spray coolant was used to prevent damaging the restoration and cooling off the disc during sectioning. Both halves were evaluated under a stereomicroscope (EGC,Russia) at 28X magnification. For each specimen, the section with greater microleakage was selected.

Scoring of marginal microleakage based on dye penetration into the occlusal and gingival margins was as follows:

Occlusal (enamel) margin:

0= No evidence of dye penetration at the tooth-restoration interface

1= Dye penetration at the tooth-restoration interface maximally extending to DEJ

2= Dye penetration at the tooth-restoration interface extending beyond the DEJ but not reaching the axial wall

3= Dye penetration at the tooth-restoration interface reaching the axial wall

4= Lateral dye penetration into dentin reaching the dental pulp

Gingival (dentinal) margin:

0= No evidence of dye penetration at the tooth-restoration interface

1= Evidence of dye penetration at the tooth/ restoration interface extending less than one-half the distance to the axial wall

2= Dye penetration along the tooth/restoration interface extending greater than one-half the distance to the axial wall but not to the axial wall

3= Dye penetration to the axial wall or beyond

4= Lateral dye penetration into dentin reaching the dental pulp

The microleakage score of specimens was recorded in special forms. Kruskal Wallis test and non-parametric Mann Whitney U test with Bonferroni adjustment were applied for statistical analysis.

Results

In this study, most specimens showed score 1 microleakage at the occlusal and gingival margins. Small number of samples showed scores 3 and 4 microleakage (Table 1). Considering the difference in the scoring system of occlusal and gingival margins, they could not be compared.

In the occlusal (enamel) margin, a significant difference was detected between the control group and the test groups (except for group 2). In inter-group comparison, only the difference between groups 3 and 4 was not statistically significant (Table 2). The lowest microleakage was observed in group 3 as 13 specimens in this group had score 1 microleakage.

Inter-group comparison of dentin margin revealed no significant difference between groups (neither test nor control groups)(Table 2). But, the lowest microleakage was noted in group 3 and all specimens in this groups had score0 or 1 microleakage.

Discussion

Composite resins are widely used for the restoration of cervical lesions due to their high esthetics, no mercury content compared to dental amalgam and the ability to bond to tooth structure by using bonding systems. The linear coefficient of thermal expansion (CTE) of composite resins is 3 to 4 times that of tooth structure. This factor in association with polymerization shrinkage causes a pressure at the tooth/restoration interface that usually leads to the formation of gap at thisarea. Composite restoration of cervical lesions has always been challenging especially where there is no enamel to bond to the gingival margin of the restoration.

Weak bond to dentin increases the risk of gap formation followed by subsequent microleakage that can cause secondary caries, marginal discoloration, pulp irritation or tooth-hypersensitivity [3, 14, 15]. In our study, delaying the polishing for 15 min had no significant effect on mean microleakage at the enamel margin but delay for 24h and one week

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Table 1. Degree of dye penetration at the occlusal and gingival margins in the 4 groups

Group	Degree of occlusal microleakage					Degree of gingival microleakage				
-	0	1	2	3	4	0	1	2	3	4
Control	0	1	21	3	0	0	13	0	2	**0**
2nd	0	3	6	5	1	0	11	0	3	**1**
3rd	1	13	1	0	0	3	12	0	0	**0**
4th	2	8	5	0	0	0	13	2	0	**0**
Total	3	25	23	8	1	3	49	2	5	**1**

Table 2. Comparison of mean microleakage at the occlusal and gingival margins

Comparison of groups	Occlusal margin	Gingival margin
Control group/2nd group	0/68	0/51
Control group/3rd group	0/001*	0/16
Control group/4th group	0/001*	0/93
2nd group/3rd group	0/001*	0/056
2nd group/4th group	0/003*	4/30
3nd group/4th group	0/38	0/16

*** Presence of a significant difference at P=0.009 with 99% CI**

significantly decreased the microleakage at the enamel margin. Since polymerization takes 24 hours to complete [12], polishing and associated thermal stress and thermal changes had no effect on the microleakage of restorations. In group 4, polymerization was complete at one week and water sorption and the resultant expansion during one week could effectively reduce microleakage.

At the gingival margin, no significant difference was found between the understudy groups. Antoniadi et al, in their study in 1991 observed that in all understudy materials, delay in finishing with different techniques led to a surface hardness equal or superior to cases where finishing had been conducted immediately after the restoration [7]. Also, TY et al, in a similar study in 1998 evaluated the effect of finishing and polishing time on surface characteristics of tooth-colored restorations and obtained similar results [16].

Guilherme et al, in 2002 reported the same results regarding the effect of time and finishing technique on the sealing ability of two composite resins. They suggested a 24h delay in finishing of microfilled composite restorations with diamond burs under wet conditions [9].

Venturini et al, in their study in 2003 on the effect of instrumentation time on microleakage of RMGIs reported decreased microleakage and recommended delayed finishing and polishing [11].

Yalcin et al, in 2006 evaluated the effect of two different polishing techniques on microleakage of three new composite resins for Class V restorations and found that resistance to microleakage in the enamel margin was not significantly influenced by the polishing system or the composite resin type but in dentin margin, microleakage was significantly affected by the mentioned two factors. The highest microleakage was found in nanohybrid composite resin while nanofilled resin had the lowest microleakage [17].

Based on the above-mentioned studies, delay in finishing and polishing is effective for both improving surface characteristics and reducing microleakage.

On the other hand, Venturini et al, in their study in 2006 on the effect o polishing techniques and time on surface roughness and microleakage of composite restorations found that a combination of composite type, time and technique of polishing affects the microleakage. But in general, immediate polishing produced no detrimental effect [10].

Cenci et al, in their study in 2008 evaluated the effect of polishing techniques and time on the surface characteristics and sealing ability of composite resins after one year of storage and found that immediate polishing had equal or superior efficacy for decreasing microleakage and surface roughness compared to delayed polishing. Also, they reported

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that microfilled composites had the least surface roughness and the greatest surface hardness after one-year period. Degree of microleakage was not significantly different among different composite resins [18].

Successful bond to enamel is almost easily achieved; whereas, a reliable bond to dentin is extremely difficult to obtain. The discussed issues can neutralize the positive effect of expansion due to water sorption. Furthermore, even if water sorption closes the gap, the tooth and the restoration at the interface are only in close proximity of one another and there is no bond between the two [19]. This study showed that if a reliable enamel bond exists, delay in finishing and polishing would successfully decrease the microleakage. However, this finding may also be attributedto the higher quality of bond to enamel and the fact that finishing and polishing stresses would have less effect on a high quality bond especially after the completion of polymerization.

Microleakage in dentin margin was low in all groups. In general, 49 specimens had score 1 microleakage and it shows that self-etch bonding applied to dentin is associated with small microleakage; and time allocated for further polymerization and delayed finishing and polishing had no positive effect on microleakage at the gingival margin.

Conclusion

Based on the obtained results, the lowest mean microleakage in both enamel and dentin margins was observed in group 3 (finishing and polishing after 24h). It is concluded that a 24h delay in finishing and polishing can probably reduce microleakage, and composite resinsneed to be polished after 24h and not immediately after the restoration.

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