

Original Article

The Effect of Cutting Efficacy of Diamond Burs on Microleakage of Class V Resin Composite Restorations Using Total Etch and Self Etch Adhesive Systems

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Abstract:

Objective: In this study, the effect of bur cutting efficacy was evaluated on microleakage of class V composite restorations with two adhesive systems.

Materials and Methods: Class V cavities were produced on sound extracted human teeth, which had been assigned randomly to one of six groups (N=15) as follows: Groups 1 and 6 were prepared using used rough diamond bur; Group 2 and 5 were prepared using new rough diamond bur; Group 3 and 4 were prepared using soft diamond bur. After application of Single Bond (3M Dental Product, USA) in groups 4,5 and 6 and Clearfil SE Bond [Kurary Medical Inc. Japan] in groups 1,2 and 3, all cavities were restored with composite resin. The teeth were thermocycled and microleakage was evaluated by dye penetration. Kruskal-Wallis and Mann-Whitney tests with Bonferroni's correction were used for statistical analysis.

Results: The results showed that gingival margins significantly leaked more than occlusal margins for all bur types and bonding systems. Using the same adhesive system in gingival margins, significant difference was seen between bur types and using the same bur type in occlusal margins, there was a significant difference between the two types of adhesive systems.

Conclusion: Cutting efficiency of bur had a great effect on microleakage of resin composite restorations. So long term use of burs may result in an increase in microleakage of composite resin restorations.

Key Words: Microleakage; Cutting Efficacy; Diamond Bur; Self Etch; Total Etch

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INTRODUCTION

Microleakage around resin composite restorations results from the formation of gaps where the restoration and the cavosurface margin of the natural tooth structure are joined. Gap formation may be related to shrinkage of the resin during polymerization[1] and/or poor adhesion of dentin bonding agents between the dentin and composite material which leads to conse-

quences, such as discoloration of the restoration, marginal break down, recurrent caries, pulpal inflammation and post operative sensitivity which may affect the longevity of restoration and ultimately the vitality of the dental pulp [2]. When we cut the tooth structure with rotary instruments such as burs, an amorphous layer of organic and non-organic debris named the smear layer covers the cavity surface. Now

it is clear that the quality and quantity of the smear layer severely depends on how it is created and in different conditions it has various properties [3-5]. Many variations in the smear layer of the prepared teeth with different dental instruments have been reported that can affect microleakage of composite resin restorations. The use of different burs to increase the surface roughness of preparations was evaluated as early as 1987. Mowery, Parker and Davis used four different grits of sandpaper to prepare the dentin surface.

They found that increasing the surface roughness may increase Bond strength primarily because of the increase in the total surface area. In addition, surface irregularities were created; subsequently, increasing the mechanical locking of resin into these irregularities.

While most of these studies concentrated on improving the bond strength of resin composites to the tooth structure, microleakage does not always decrease in direct proportion to increased bond strength [6].

Many studies indicate that the quality and quantity of the smear layer is different when we use high speed or low speed cavity preparation devices or when we use different cutting instruments [3-5]. Therefore, adhesion will be different in different studies. Formation of the smear layer by various diamond burs with different grits was evaluated by Tani et al.

He understood that the smear layer which covered the dentin when preparing with 50-150 grit diamond bur is thicker than the smear layer formed with 15-30 grit diamond bur. He also revealed that using different adhesive systems have affected the microleakage of composite restorations [7]. It is established that multiple use of disposable diamond burs can affect microleakage behavior [8]. Studies have evaluated different dentin bonding agents designed to improve the bond between the tooth structure and restorative materials. Bonded enamel is generally reliable in decreasing microleakage; however, bonded dentin is not as predictable at reducing microleakage of the gingival margins at or near the cement-enamel junction.

Dentin bonding agents have substantially reduced microleakage in the gingival margin but have not eliminated it completely [9]. Deliperi and others compared the degree of microleakage in self etch and total etch adhesive systems. They reported that I-Bond, the one step self etch adhesive system, has more dye penetration in both gingival and occlusal margins and there was no significant difference between occlusal and gingival margins in XenoIII (one step self etch adhesive), NT (total etch adhesive) and I-Bond (one step self etch adhesive). On the other hand Clearfil SE Bond had more dye penetration in the occlusal margin than the gingival margin [10].

In different studies, it has been revealed that the cutting efficacy of cutting instruments is reduced while applying [11,12] and it may affect the quality and quantity of the underlying smear layer.

Therefore, this study evaluated the effects of cutting efficacy of different diamond burs on the microleakage of resin composite restorations using total etch and self etch adhesive systems, and it also determined whether or not bur cutting efficacy had an impact on the results.

Table 1. Scoring system for microleakage.

Microleakage Score	Degree of Dye Penetration
0	No dye penetration
1	Dye penetration less than half-way to the axial wall
2	Dye penetration greater than half-way to the axial wall
3	Dye penetration along the axial wall

MATERIALS AND METHODS

Ninety non-carious extracted human third molars, stored in 0/2% thymol solution after extraction, were cleaned of calculus, soft tissue and debris with hand instrumentation.

In order to omit the inter-operator bias, all the teeth were prepared and restored by a single operator.

Prior to preparation, each facial surface of the 90 teeth was numbered. Each sample was assigned randomly in equal numbers (n=15) to one of six groups.

Conservative class V composite preparations were made using one of three different burs; a coarse new diamond bur, a coarse used diamond bur and a fine diamond bur in an air/water cooled high speed headpiece (CH-4T5NSK B2/B3, Japan A1101800). A new bur was used for every five preparations.

The cavity preparations were standardized with a width of 3 mm and a height of 2.5 mm and a depth of 1.5 mm.

The occlusal wall of the cavity was limited in the enamel wall and the gingival wall of the cavity was extended beyond the CEJ onto the cementum.

The occlusal and gingival cavosurface margins were sharp and non-beveled. No additional mechanical retention was placed. After finishing the cavity preparation and before restoration, a different bonding system was used for each group.

First group: teeth were cut with used coarse diamond bur (Tizkavan-Iran) and were conditioned with Clearfil SE Bond (Kuraray Medical Inc. Japan PEF #1975-WD Batch No: 1-primer: Lot 00670A2-Bond: 00957A) adhesive system.

Table 2. Microleakage raw data scores by the examiner

Gingival						
Microleakage Score	Used-SE	New-SE	Soft-SE	Soft-SB	New-SB	Used-SB
0	1	0	1	0	3	0
1	2	10	5	4	8	2
2	6	4	3	7	3	4
3	6	1	6	3	1	9
	15	15	15	14	15	15
Occlusal						
	Used-SE	New-SE	Soft-SE	Soft-SB	New-SB	Used-SB
0	1	2	8	4	8	11
1	8	5	2	2	3	3
2	3	6	4	8	4	0
3	2	2	1	0	0	1
	14	15	15	14	15	15

Second group: teeth were cut with new coarse diamond bur (Tizkavan-Iran) and were conditioned with SE Bond adhesive system.

Third group: teeth were cut with fine diamond bur (Komet Brasseler Germany) and were conditioned with SE Bond adhesive system.

Fourth group: teeth were cut with fine diamond bur and were conditioned with Single Bond (3M Dental Product ST. Paul. Batch No: 6KR) adhesive system.

Fifth group: teeth were cut with new coarse diamond bur and were conditioned with Single Bond adhesive system.

Sixth group: teeth were cut with used coarse diamond bur and were conditioned with Single Bond adhesive system.

All prepared cavities were washed for 15 seconds with an air/water spray and the excessive water was removed with a gentle air spray, leaving the preparation slightly moist. SE Bond adhesive system was applied for the cavities of group 1, 2 and 3, according to the manufacturer's instruction the primer was applied in the cavity, 10 seconds air dried gently, then applied a single layer bond in the cavity, the bonding agent was thinned with intermittent one-to-two second air blasts, which was followed by 20-second light polymerization by a LED light curing unit (LED Turbo light cure- Taiwan) with 600 mw/cm² light intensity.

Single Bond adhesive system was applied for the cavities of group 4,5 and 6, according to the manufacturer's instruction, 20 seconds total etch time of the enamel, dentin and cementum with Ultra Etch 37% phosphoric acid (Ultraetch® 505 WEST 10200 South SOUTH Jordan ,UTAH 84095 Ultradent, USA), 15 seconds rinse, then a light one-to-two seconds stream of air leaving the surface slightly moist. This was followed by applying Single Bond into the preparation and rubbing the bonding resin into the dentin enamel and cementum with the applicator brush tip. Single Bond was thinned with intermittent one-to-two second air blasts to the point of not losing its glossy appearance. This was followed by 20 second light polymerization using an LED light curing unit (LED Turbo light cure-Taiwan) with 600 mw/cm² light intensity. In all groups, the composite restorative material (Z100-3M, shade A2 USA) was placed and condensed incrementally until the preparations were completely filled. Each increment of restorative material attempted to involve only two walls of the preparation to reduce shrinkage and direct stress strain away from the internal walls. Each increment was light polymerized for 20 seconds prior to placement of the subsequent increment. All specimens were then subjected to 500 thermocycles at 5°C, 55°C with a 20 second dwell time.

Table 3. Mean rank and means of dye penetration±(SD) for the experimental groups at occlusal and gingival margins

Cutting Bur/ Bonding Agent		Used-SE	New-SE	Fine-SE	Fine-SB	New-SB	Used-SB	P-value
Occlusal Margin	Mean rank	54.75	57.07	39.83	51.57	37.20	27.73	0.005
	Mean+/- SD	1.4286+/- 0.8516)	1.5333+/- (0.9155)	0.8667+/- 0.0601)	1.2857+/- (0.9139)	0.7333+/- (0.8837)	0.4+/- (0.8281)	
Gingival Margin	Mean rank	53.60	32.43	47.80	47.39	26.90	62.03	0.001
	Mean+/- SD	2.1333+/- (0.9155)	1.4+/- (0.6325)	1.933+/- (1.0328)	1.9286+/- (0.73)	1.1333+/- (0.8338)	2.4667+/- (0.7432)	

All specimens were then subjected to 500 thermocycles at 5°C and 55°C with a 20-second dwell time (Vafaei-Iran).

After 24 hours all the restorations were finished, although the required finishing was minimal. After cycling, the apices of all root surfaces were sealed with adhesive wax and two coats of finger nail were applied to within approximately 1 mm of the tooth-composite interface. After sealing, the teeth were immersed in a 5% solution of methylene blue dye for 12 hours. Upon retrieval from the dye, the teeth were washed under running water and left to dry for dye fixation.

The embedded samples were then sectioned once vertically approximately midway through the facial surface using a diamond coated cutting disk and Nonstop section machine (Bego Nonstop-Germany).

Dye penetration was evaluated using a 10X stereomicroscope (M6C- 10- Germany) at the occlusal and gingival margins. Microleakage scores were based on the degree of dye penetration according to the criteria described in Table 1.

Microleakage scores were recorded for both the occlusal and gingival margins as shown in Table 2.

Table 4. Mann-Whitney U pairwise comparison test

Occlusal Margin	Mean Rank	P Value	Gingival Margin	Mean Rank	P Value
Soft-SB	18.86	0.018	Soft-SB	12.04	0.07
Used-SB	11.40		Used-SB	17.77	
New-SB	17.17		New-SB	10.03	
Used-SB	13.83	0.305	Used-SB	20.97	0
Soft-SB	17.43		Soft-SB	18.86	
New-SB	12.73		New-SB	11.04	
Used-SE	17.57	0.123	Used-SE	16.30	0.624
Soft-SE	12.60		Soft-SE	14.70	
Used-SE	14.29		Used-SE	19.27	
New-SE	15.67	0.683	New-SE	11.73	0.019
New-SE	18.27		New-SE	13.13	
Soft-SE	12.73		Soft-SE	17.87	
New-SE	18.9	0.033	New-SE	16.97	0.367
New-SB	12.10		New-SB	14.03	
Used-SE	20.11		Used-SE	13.93	
Used-SB	10.23	0.001	Used-SB	17.07	0.345
Soft-SE	13.33		Soft-SE	15.17	
Soft-SB	16.79		Soft-SB	14.82	

The Kruskal-Wallis for non parametric data was used to analyze inter group comparisons of microleakage, while Mann-Whitney U and Wilcoxon W tests with Bonferoni's correction were used to test for differences in microleakage between pairs of groups in dentin and enamel margins.

RESULTS

Microleakage raw data scores by examiners are presented in Table 2. Mean rank and means of dye penetration for the experimental groups at occlusal and gingival margins are presented in Table 3. Results of the Kruskal-Wallis are presented in Table 3. Kruskal-Wallis test showed that new/SE group has the most and used/SB group has the least microleakage in the occlusal margin (P-value=0.05). In the gingival margin new/SB group has the least and used/SB group has the most microleakage as shown in Table 3. The Kruskal-Wallis test revealed that using the same adhesive system in gingival margins, significant difference was seen between bur types. The SE Bond adhesive system had the most leakage in the used diamond bur and the least leakage in new diamond bur (P-value=0.05). The Single Bond adhesive system had the most leakage in the new diamond bur and the least leakage in the used diamond bur (P-value=0.001). The Kruskal-Wallis test revealed that using the Single Bond adhesive system in occlusal margins, significant difference was seen between bur types (P-value=0.029). The results showed that using the SE Bond adhesive system in occlusal margins there was no significant difference between bur types (P-value=0.127). The Mann-Whitney test was used to test for differences in microleakage between pairs of groups in gingival and occlusal margins. The results have been shown in Table 4. The Mann-Whitney test with Bonferoni's correction showed that using the same bur type in occlusal margins, there was a significant difference (P-value<0.0055) between used SE and used

SB groups. The SE Bond adhesive system showed more leakage than the Single Bond adhesive system. There was no significant difference using the same bur type in gingival margins between two types of adhesive system. The Mann-Whitney test with Bonferoni's correction was used to compare microleakage at the occlusal and gingival margins of the samples for each group. The results showed that the gingival margins leaked significantly more than the occlusal margins in the used SB group (P-value=0.000).

DISCUSSION

Reviewing the previous literature makes it clear that the efficiency of the instrument used for cavity preparation has great effect on quantity and quality of the smear layer and the amount of leakage in cavities prepared with burs having different efficiency is not the same [13]. In 2005, Von Fraunhofer evaluated the effect of re-using of disposable diamond burs on restoration leakage. He showed that leakage of the first and third uses of the bur were similar to each other, but was much greater for the fifth use. He said that disposable diamond burs can cut preparations in up to three teeth before adversely affecting leakage behavior [8]. Oliveria reported that the roughness of the surface varied strongly with the degree of coarseness. The surface roughness and also the thickness of the smear layer increased significantly with the coarseness of the abrasive but did not differ significantly with the abrasive type. Evaluating the smear layer modification; they found a significant inverse association between the degree of coarseness and the tubule openness. Thicker smear layers resulted in an increased number of closed tubules after SE treatment [14]. The SEM study carried out by Sanitini et al suggested that the smear layer produced by rough diamond burs were consistently thicker than those produced by tungsten carbide fissure burs, which in turn were thicker than those

produced by fine diamond burs. Using the inverted cone at speeds of 6000 rpm without water spray, consistently produced the thinnest smear layers. The research says that an understanding and recognition of appropriate treatment of smear layers is crucial to the development of improved dentin bonding systems [15]. The research results showed that gingival margins leaked more than occlusal margins for all bur types. This finding shows the same results as previous studies[2,9,16,17].

Dentin is a main contributor in reducing microleakage. As well as organic in its nature, dentin is a complex structure of collagen and dentinal tubules. There is significant difference between the reaction of wet and dry collagen [18]. Depending on the location of the preparation, the size, number and direction of dentinal tubules are different. Dentin tubules may be absent if the preparation ends at the CEJ or below; this will affect the bond and also microleakage [9]. In the SE Bond group, we found that the used diamond bur had more leakage than the new diamond bur, which may be the result of the quality of the smear layer, which is unlike in different bur types and high pH of self etch primer in this system.

Vonfraunhofer related the higher restoration leakage in multiple uses of the disposable bur to the effect of greater smearing of the surface of cavity preparation together with some redeposition of cutting debris on the surface from the repeatedly used bur [18]. We also found that when the same adhesive systems were used, there was significant difference between bur types in dentin margins, so when the Single Bond adhesive system was used, the used diamond bur had the most and a new diamond bur had the least microleakage and it had the same results when we used the SE Bond adhesive system. This might suggest that the smear layer which is produced by used diamond bur is denser and stickier, because of the low rate of efficiency, in order to prepare the cavity, more pressure of the hand is used by the den-

tist unintentionally [19]. But when the bur types were the same in dentin margins, there was no significant difference between different adhesive systems. The results of this study revealed that using the same adhesive system in enamel margins caused no significant difference between bur types. But when the same bur type was used, there was significant difference between the types of adhesive systems. The SE Bond adhesive system had more leakage than the Single Bond adhesive system.

This might show that the phosphoric acid etchant in Single Bond system can totally remove the smear layer and resin can easily infiltrate into the demineralized space. But as the pH value of self-etching/priming solution in SE Bond system is generally low enough to demineralize the smear layer and the underlying dentinal surface [20], we have more leakage in SE Bond system than the Single Bond system. Pashley and Carvalho suggested that the smear layer interferes with the self-etching primer adhesion [21]. Our results support this suggestion.

CONCLUSION

In conclusion, the cutting efficiency of bur had a great increasing effect on microleakage of composite resin restorations. So long term use of burs may result in an increased microleakage of composite resin restorations. On the other hand, the adhesive type was effective on the leakage of composite restorations. The SE Bond adhesive system has more leakage than the Single Bond adhesive system.

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