Microleakage of Composite Restorations Following Chemo-mechanical and Conventional Caries Removal

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Statement of Problem: Microleakage is the most important factor in composite restorations failure, resulting in marginal degradation, marginal staining, secondary caries and pulp damage. One of the factors that influence microleakage is the method of caries removal. Convention rotary instrumentation generates smear layer on the dental surface, whereas chemo-mechanical caries removal increases surface roughness.
Purpose: The aim of this study was to compare the microleakage of composite restorations following caries removal via conventional versus chemo-mechanical methods.
Materials and Methods: One hundred class V carious human posterior teeth were randomly divided into two equal groups. Caries were completely removed with carbide burs in group one and according to manufacturer's instruction in chemo-mechanical group (Carisolv group or group two). Then the same composite restorative material, followed by finishing and polishing, filled all the cavities. Subsequently the specimens were thermocycled and then placed in dye solution. The teeth were sectioned through the restorations and evaluated for microleakage scores using a stereomicroscope. The data were analyzed using Mann-Whitney-U test.
Results: Prevalence of scores 0 and 1 of microleakage in occlusal margins in group one was 80% and 20%, respectively and in group two 74% and 36%, respectively. Prevalence of scores 0, 1 and 2 of microleakage in gingival margins in group one was 56%, 36% and 8%, respectively and 42%, 42% and 16% in group two, respectively. Scores 3 and 4 of microleakage were not seen in any of the groups. Statistical analysis showed significant difference in microleakage between occlusal and gingival margins in each group ($P<0.05$) but not between the two methods ($P>0.05$).
Conclusion: The results from this study indicate no significant difference in microleakage between conventional and chemo-mechanical caries removal methods.

Key Words*:* Carisolv; Microleakage; Composite; Chemo-mechanical caries removal

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Techniques of caries removal include conventional caries removal, air abrasion with aluminum oxide, atraumatic restorative therapy (ART), lasers and chemo-mechanical caries removal (CMCR). The last production of this category (CMCR) is Carisolv system that was introduced in 1998 by Mediteam Company in Sweden. In this system the dental caries is dissolved first in a chemical manner and then is removed by gentle mechanical excavating using special hand instruments.(1)

Several investigations have been done concerning the effect of Carisolv on sound dentin and it has been shown that Carisolv had

no effect on sound dentin and selectively removed the infected dentin.[2] One of the most important requirements for longevity of a restoration is marginal seal.[3] The created dental surface and left smear layer are various in different methods of caries removal.[4]

The results from studies about produced smear layer by chemo-mechanical systems are different. Some SEM studies have shown that Carisolv removed the smear layer leaving opened dentin tubules,[5-8], and on the contrary some indicate that there have been no opened tubules after Carisolv application.[4,9] In a topographic evaluation using atomic force microscopy (AFM) and contact profilometry it has been shown that Carisolv left a more rough dentin surface compared to bur. [10]

Neguyen et al evaluated the effect of Carisolv on microleakage of composite restoration and didn't find any differences between Carisolv and bur caries removal effect.[11]

In a study carried out by Kubo et al, nanoleakage of three dentin adhesive systems bonded to Carisolv treated dentin was evaluated and silver deposition occurred along the base of the hybrid layer for all specimens. [12]

The purpose of this study was to compare the microleakage of composite restorations following, caries removal via conventional or chemo-mechanical method.

Materials and Methods

One hundred extracted human molars and premolars with class V carious lesions in one third of buccal and lingual surfaces were collected, cleaned using scalpel and stored in 0.2% thymol solution.

The occlusal margins of lesions were in enamel and the gingival borders in cementum.

The selected teeth were divided randomly into two groups each of 50. Group 1 was subjected to conventional caries removal using suitable carbide round burs with a low speed rate. Finally the fragile enamel of margins was finished using NO: 2 round diamond burs (D and Z, Germany) in a high-speed handpiece and coolant stream. In another group (group 2) the carious lesions were removed using Carisolv system (Mediteam, Sweden) according to manufacturer's instruction.

While applying pressure on the twin syringe mixing system, equal amount of two components was mixed.

The mixed gel was applied to the carious dentin using special hand instrument and left for 30 seconds. The softened carious dentin was then removed by careful excavation with special non-cutting hand instrument. This procedure was repeated until the Carisolv gel was not longer cloudy and dentin surface felt hard when probed with a sharp dental explorer NO: 2.

Finally in some cavities the remained fragile enamel margins were finished using NO: 2 round diamond bur in a high-speed hand piece.

All prepared cavities in the two groups were restored in a similar manner using Single Bond dentin adhesive (3M Co.; USA) and A_3 shade of Z100 composite resin (3M Co.; USA) as following steps.

Step 1: 35% phosphoric acid gel (Scotch bond gel 3M, USA) was applied first to the enamel margins for about 15 seconds and then to the dentin surfaces for about 15 seconds.

Step 2: The cavities were washed for about 10 seconds using water jet spray and then dried for about 5 seconds using oil free air spray.

Step 3: Rewetting the cavities was done by wet cotton pellets (wet bonding technique).

Step 4: Single Bond adhesive agent was applied into the cavity walls and gently air thinned for about 5 seconds.

Step 5: The step 4 was repeated and finally the adhesive cured for about 20 seconds using Coltolux 2.5 unit (Coltene, Germany) with 500mW/cm^2 output.

Step 6: The cavities were filled using Z100 composite resin (3M ESPE Co.; USA) and were cured under pressure of Mylar strip for about 40 seconds. The cavities deeper than 2 mm were filled and cured in two increments.

Step 7: The restorations were finished using sof-lex discs (3M ESPE Co.; USA) from a coarse to a fine one.

Each disc was used only for finishing 5 restorations. Finally all the samples were stored in 37ºC-distilled water inside the incubator unit for 24 hours, and then thermocycled in 5ºC and 55ºC water with a dwell time of 20 seconds for 500 cycles.

Step 8: The root apices and furcations were sealed using sticky wax named as model cement (Kem Dent, England) and the tooth surfaces were covered using two coats of nail polish except the surface of restorations and 1.5 mm around them. The specimens were immersed in 0.5% basic fuchsine solution for 24 hours and then removed from dye solution and washed under running water.

Step 9: The teeth embedded in Meliodent cold cure acrylic resin (Bayer, Germany) and were split in occlusogingival direction by a sectioning machine (Vafaei industrial factory) under running water.

The corresponding sectioned splits were examined under a stereomicroscope (wild M8, Wild Co. Model MMS 235, Swiss) at 18x magnification to determine microleakage scores and penetrating microleakage. The following scoring criteria were used.

0: No dye penetration

1; Penetration of dye into the one third of occlusal and gingival interface.

2: Penetration of dye into the two third of occlusal and gingival interface.

3; Penetration of dye even the axial wall.

4: Penetration of dye into the axial wall.

The microleakage scores were analyzed by Mann Whitney test using SPSS software.

Results

Scores 0 and 1 of microleakage in occlusal margins were seen in 40 (80%) and 10(20%) of group one and in 37(64%) and13 (26%) of group two, respectively (Table I). There were no differences between microleakage scores at occlusal margins of two groups (P=0.478). Scores 0, 1 and 2 of microleakage in gingival margins in group one were 56%, 36% and 8%, respectively and 42%, 42% and 16% in group two, respectively. Scores 3 and 4 of microleakage were not seen in any of the groups. There was no significant difference in gingival microleakage between the two groups (P=0.119) (Table II).

Table I- Microleakage of bur and Carisolv groups in enamel

Groups	Microleakage score				
	0	**1**	**2**	**3**	**4**
Bur	40	10	0	0	0
Carisolv	37	13	0	0	0

Table II- Microleakage of bur and Carisolv groups in dentin

Groups	Microleakage score				
	0	**1**	**2**	**3**	**4**
Bur	28	18	4	0	0
Carisolv	21	21	8	0	0

Discussion

Marginal seal plays a major role in success of restorations. Marginal discoloration, recurrent caries, marginal deterioration and pulp damage can occur as a result of marginal leakage.[3] Polymerization shrinkage, bonding to tooth structure , modulus of elasticity, water sorption and coefficient of thermal expansion of composite resin have a pronounced effect on the marginal seal of composite restoration.[13]

Different procedures of caries removal leave distinct different surface texture and smear layer thickness of excavated dentin can affect the quality of bonding to dentin and marginal seal.[4]

Regarding the clinical effect of Carisolv system on microleakage of composite restorations and insufficient present studies on this matter, more researches are needed to perform. The results of this study showed that there was a more considerable degree of leakage in dentinal (gingival) than enamel (occlusal) margins either

in conventional (group 1) or chemo-mechanical method ($P<0.05$). This finding accords the results of other studies in this field.[14,15]

Usually microleakage in enamel (occlusal) margins is less than dentinal (gingival) margins because the enamel interfaces show a better resistance against polymerization shrinkage forces.[3,15] This resistance will lead to crazing in enamel margins. If shrinkage forces overcome the dentin bond strength, it will produce marginal gap usually is seen in root surfaces.[16]

Shrinkage of composite resin may cause some changes in newly formed hybrid layer that are generally, in surface layer of dentin adjacent to the interface. The bond strength and sealing ability in this area is week that can be due to the less dentinal tubules and consequently less resin tag formation, though a study has shown that superficial dentin resin tags play no major role in bond strength.[17,18]

It has been shown that performed hybrid layer on superficial cervical dentin is thinner than deeper one.[19] Although according to some investigations there is no correlation between hybrid layer thickness and bond strength, however either lack of hybrid layer or its discontinuity can decrease the bond strength and marginal seal.[12, 20]

The results of this study showed that there was no meaningful difference in the degree of leakage between two methods of caries removal as has been shown in a study done by Ngujen.[11] Besides, the percentage of penetrating microleakage in dentinal margins in two methods of caries removal was similar. There was no penetrating microleakage in enamel margins in either above methods.

The created smear layer and dentin surface texture may vary in chemo-mechanical and bur caries removal. Some scanning electro microscopy (SEM) investigations on affected dentin have shown that Carisolv removed the smear layer and opened the tubules. [5-8]

One the contrary some investigations have found that Carisolv failed to remove the smear layer and no patent dentin tubules were visible.[4,9]

Other studies have reported that a minimal smear layer occurred and tubule orifices appeared patent after chemo-mechanical caries removal with Carisolv. In view of these diverse results it appears that the chemo-mechanical caries removal system is technique sensitive and shows operator variability.

In a SEM study, it has been shown that bur excavation leaved smooth texture. [4]

There are different statements about the surface roughness leaved by Carisolv treatment. In an investigation by AFM (Atomic force microscopy) and contact profilometry it has been shown that Carisolv left a rougher surface and a more porous intertubular dentin, compared to that leaved by bur. [10]

This is in contrast with other studies that have reported that there was no difference in dentin surface texture created by conventional or chemo-mechanical caries removal. [21]

Kubo et al believe that chemo-mechanical caries removal has no adverse effect on bonding to dentin and also etched dentin surfaces created by 35% phosphoric acid in the abovementioned methods are similar. [12]

The results of performed researches corroborate that the composite bond strength to dentin surface created by chemo-mechanical and conventional are approximately similar. [22,23]

Although there was no meaningful difference in degree of leakage between group 1 and group 2 in the present study, the degree of leakage in group 2 seemed to be more than that of group 1 and could be caused by following factors:

1- The remained Carisolv gel in prepared cavity can interfere with the effect of applied acid. Some studies have shown the remnant of Carisolv gel despite water irrigation. [2,21]

2- There is probable reaction between Carisolv gel and etching agent (phosphoric acid).

3- Using Carisolv gel and phosphoric acid together can demonetarized tooth structure more

deeply compared to caries bur excavated and etched dentin, that the bonding agent can not penetrate completely and leaves the collagen fibers unsupported in some area beneath performed hybrid layer. This condition can compromise bond quality and durability. The results of a SEM study corroborates the presence a more deeply demineralization following phosphoric acid etching in chemo-mechanical caries removal compared to conventional method. In general most of performed researches about microleakage and bond strength have been done on healthy dentin, whereas in clinical situations most of dentin substrates are of affected dentin.

In our study the obtained results about composite resin restorations were on affected dentin that is close to clinical situation. Affected dentin structure is different form normal dentin. There are less mineral contents in affected dentin compared to normal dentin following acid attack, also its hardness is less than normal dentin and the dentin tubules have been filled with whitlockite crystals that have more resistance against etchant agents.[24]

The bond strength of affected dentin after conventional caries removal procedure is usually less than normal dentin and probably the glycoproteins or mucopolysacarids present in peritubular dentin interfere with the wetting or degree of polymerization of the resin-bonding agent. [25, 27]

The performed hybrid layer by most adhesive agents among all single bond to affected dentin is thicker than normal dentin though there is no relation between bond strength and thickness of hybrid.[25]

In general the performed resin tags on affected dentin are smaller with thicker hybrid layer in contrast to normal dentin. The structural and physical specialty of exposed collagen fibers following phosphoric acid etching in affected dentin differs from normal dentin so further studies are needed regarding microleakage and bond strength of affected dentin.

Conclusion

It would seem that the use of Carisolv doesn't adversely affect the microleakage of composite restorations. The interactions between Carisolv treated dentin surface and different bonding systems, including self each adhesive should be evaluated in micro tensile test. Further research is required to study the hybrid layer and characteristics of resin/dentin interface following chemo-mechanical caries removal method.

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