Effect of dispensing method and curing modes on the microleakage of composite resins

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ABSTRACT

Background: Vibration decreases the viscosity of composite, making it flow and readily fit the walls of the cavity. This study is initiated to see how this improved adaptation of the composite resin to the cavity walls will affect microleakage using different curing modes

Materials and methods: Standard Class V cavities were prepared on the buccal surface of sixty extracted premolars. Teeth were randomly assigned into two groups (n=30) according to the composite condensation (vibration and conventional) technique, then subdivided into three subgroups (n=10) according to light curing modes (LED-Ramp, LED-Fast and Halogen Continuous modes). Cavities were etched and bonded with Single Bond Universal then restored with Filtek® Z350 (3M ESPE, USA). In the vibration group, condensation was done using Compothixo™ (Kerr, Switzerland). In the conventional group, condensation was done with hand plugger. Curing modes for all groups were LED-Ramp, LED-Fast and halogen continuous modes, respectively. Samples stored in distilled water at 37°C for seven days, and painted completely with two layers of nail varnish with only 1 mm around the composite restoration left. Samples were thermocycled, immersed in 2% methylene blue solution for 3 hours, and sectioned longitudinally. Dye penetration was assessed under a stereomicroscope. Data were analyzed by Kruskal-Wallis and Mann-Whitney U tests with $p < 0.05$ considered significant.

Results: Vibration group showed less microleakage (P=0.028). In the conventional group there were no differences by using different curing modes (P=0.277). In the vibration group no differences were found between LED-Ramp and LED-Fast mode (P=0.989). However, there were significant differences between LED-Fast and halogen (P=0.05) and between LED-Ramp and halogen group (P=0.001). Microleakage scores of all cervical walls were higher than the occlusal walls (P=0.001). Occlusal walls leakage for conventional and vibration groups were not different (P=0.475), while there were significant differences between them at cervical walls (P=0.001).

Conclusion: Vibration with LED-Ramp curing mode may decrease marginal leakage of composite restoration placed in Standard Class V tooth preparations.

Key-words: Composite resin, Vibration, Condensation, Compothixo, Microleakage, **(Received: 19/12/2019; Accepted: 20/1/2020)**

INTRODUCTION

Composites resins are the most commonly used restorative material.[1,2,3] However, multiple clinical restrictions affect the widespread of this material.[1] The major constraints that affect the longevity of composite resin are polymerization shrinkage and stress-causing microcracks within the body of the filling which can be fractured easily and marginal gap leading to microleakage, bacterial invasion,[1,4,5] secondary caries, marginal staining, discoloration, tooth sensitivity, inflammation of the pulp, and loss of all or part of the restoration.[1,3,6-9]

SonicFill System use sonic energy decreases the viscosity of the filling to about 87% which will improve the adaptability of the filling to the cavity walls. After stopping the sonic energy, the decreasing polymerization shrinkage and microleakage can be achieved by many modifications in the composition of the filling materials, light curing mode and condensation procedures.[10,11,12] LED light curing systems giving several benefits over traditional halogen curing units used in composite fillings in that they cure composite more rapidly, produce less heat, consistent output over time and more longevity. Conventional halogen needs more curing times and their parts may be exhausted causing inadequate output and heat generation. [13-20]

Vibration lowers the viscosity of composite, and increases adaptation to tooth aiming in reducing microleakage. Ultrasonic vibration of the uncured composite resin at room temperature increases flowability and improves cavity walls adaptation. Different devices have been used to decrease composite viscosity, such as SonicFill® (Kerr/Kavo, USA) and Compothixo™ (Kerr Dental, Switzerland).

composite returns to its normal viscosity and becomes suitable for contouring and carving.[21]

Compothixo™ is used to condense composite with vibration frequency. It is like a dental carver for composite. Compothixo consists of four tip handle: pointed, spatula, plugger and semi-sphere tips. The button on the handle is used to activate

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the device, which must gently touch the composite materials.[22]

The aim of this study was to determine the effect of composite placement technique namely vibration using Compothiox (Kerr) plugger as compared to conventional hand plugger condensation on the microleakge of composite restoration placed in class V tooth preparation that cured using three different curing modes (LED-Ramp, LED-Fast and halogen continuous).

MATERIALS AND METHODS

Sixty non-carious human premolars freshly extracted for orthodontic purpose were collected and stored in 0.2% thymol solution at room temperature until used. The routine prophylactic procedure was carried out with a rubber cup and pumice slurry for all teeth. All teeth with cracks, fracture or pigmentation were excluded.

Standard class V cavities were prepared on the buccal surface of all 60 premolars, using #245 carbide burs (D-Flex, Germany, CE8120) using a high-speed hand-piece with a copious amount of water coolant. Bur was changed after each cavity preparation. Dimensions of the cavity preparation were kept approximately to mesio-distal width of 3 mm, occluso-gingival height of 2 mm and pulpal depth of 2 mm by using a small ruler. All cavity margins were kept in enamel. Williams periodontal probe was used for checking the measurements. To decrease the errors only one operator prepared all teeth.[4,23,24,25] The teeth were then randomly classified into two main groups according to the condensation protocol to be used; vibration and conventional (n=30 each). Those two groups further divided into three subgroups (n=10 each) according to light curing modes; LED-Ramp mode, LED-Fast mode and halogen in continuous mode.

The cavities were treated with 37% phosphoric acid (DenFil™ Etchant-37, Korea) for 15 seconds, rinsed for 15 seconds with distilled water, then gently dried for 5 seconds. Single Bond Universal (3M ESPE) was applied using a disposable clean brush by painting the prepared cavity for 10 seconds, gently dried, then cured for 20 seconds. All groups were filled with the composite material (Filtek™ Z350, 3M ESPE) according to the manufacturer's instructions. The material was inserted in one increment and cured. In the vibration group, condensation of the composite was performed using Compothixo™ plugger tip (number 5405, Kerr), while in the conventional group the condensation was performed using conventional hand plugger (SMIC S.S.2).

For the LED curing light (Mini LED Acteon, France) the intensity, as measured by a light meter, was 1250 mw/cm^2, while that for the halogen light (Coxo-dental halogen curing unit CBC-682) was 1500 mw/cm^2. For all modes (LED-Fast, LED-Ramp and Halogen continuous) the curing time was 40 seconds following the manufacturer's instructions.

The restorations were finished with fine and extra-fine finishing diamond burs (Diatech Dental AG, Heerbrugg, Switzerland) used in a high-speed handpiece under constant air/water coolant and polished with sequential aluminium oxide discs. All restored teeth were stored in 37°C distilled water for 1 week using an incubator. [2,14]

Thermocycling was done to simulate the temperature changes that take place in the oral cavity that might result in changes in the micro space between the tooth and the restoration. The procedure was done by cycling the teeth between two water baths: one bath maintained at 5ºC (±0.5°C) and the other at 55ºC (±0.5ºC), with a dwell time of 15 seconds. The number of cycles was 500 cycles according to the international organization for standardization.

The apices of the roots were sealed with wax and then the teeth were covered with two coats of nail varnish except for 1 mm around the margins of the restoration. This is a well-known standardized procedure for leakage studies. Nail polish was painted all over the tooth after sealing any tooth opening. Teeth were immersed in 2% methylene blue solution for 3 hours. (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4963767/)

The teeth were longitudinally sectioned using microtome (Minitome, Struers, Copenhagen, Denmark) (Figure 1). For each tooth, there were two readings, one for each half (n=20). Dye penetration was assessed under a stereomicroscope (10X). Dye penetration was scored for both enamel and dentin margins on a scale from 0 to 4.[26]

Score 0= no microleakage.

Score 1= dye penetration within 1/3 of cavity wall.

Score 2= dye penetration within 2/3 of cavity wall.

Score 3= dye penetration within the last 1/3 of cavity wall up to the axial wall.

Score 4= dye penetration spreading along the axial wall.

Figure 1: Minitome, Struers, Copenhagen, Denmark.

Multiple group comparisons were performed using the nonparametric Kruskal-Wallis test. The P value between different test groups was calculated by using the Mann-Whitney test with Bonferroni correction. P value of less than 0.05 indicated a significant difference.
In this study we assigned a score for different extends of leakage, therefore, it is not a parametric test since there was no actual numerical measurement.

RESULTS

Data analysis showed that there were statistically significant differences between two main groups, with less microleakage in vibration group (Table 1).

Table 1: Distribution of the overall microleakage scores of the conventional method compared to that of vibration method.

Microleakage score	Conventional hand plugger (n= 60)	Vibration using Compothiox (n= 60)
0	0	13
1	38	30
2	19	15
3	3	2
***P* value**	0.028*	

*** Using Mann Whitney test.**

The microleakage score of each curing mode by vibration technique was compared with the microleakage score of the same mode by conventional technique. Using LED-Ramp curing mode resulted in highly significant less microleakge when it was combined with vibration condensation technique (P<0.001), while the leakage was not significantly different in both placement techniques when the composite was cured with LED-Fast (P=0.171) and halogen light curing units (P=0.358) (Table 2).

Table 2: Microleakage scores of each curing mode by the two condensation methods.

Microleakage score	Vibration# LED-Ramp (n=20)	Conventional$ LED-Ramp (n=20)	Vibration LED-Fast (n=20)	Convent. LED-Fast (n=20)	Vibration Halogen (n=20)	Conventional Halogen (n=20)
0	4	0	7	0	2	0
1	15	14	8	14	7	10
2	1	3	4	6	10	10
3	0	3	1	0	1	0
P value	< 0.001*		0.171*		0.358*	

*** Using Mann Whitney test.**
 # Vibration: Using Compothixo plugger for composite condensation.
$ Conventional: Using hand plugger for composite condensation.

Another comparison between the microleakage score performed, between the different light curing modes for each condensation technique. Using the Kruskal-Wallis test there was a significant difference in the microleakage score between the light curing mode by using the vibration technique (P=0.011).
Using Mann Whitney test the result showed that there was a significant difference in the microleakage score between LED-Fast and halogen curing mode (P=0.05). And there was highly significant difference between LED-Ramp and halogen curing mode (P=0.001). The difference in the microleakage score between LED-Ramp and LED-Fast was not significant (P=0.989) (Table 3).
The difference in the microleakage score by using conventional technique was not significant between the three-curing mode (P=0.277) (Table 3).

Table 3: Microleakage scores of vibration and conventional condensation methods using three light curing methods.

Microleakage score	Vibration# method			Conventional$ method		
	LED-Ramp (n=20)	LED-Fast (n=20)	Halogen (n=20)	LED-Ramp (n=20)	LED-Fast (n=20)	Halogen (n=20)
0	4	7	2	0	0	0
1	15	8	7	14	14	10
2	1	4	10	3	6	10
3	0	1	1	3	0	0
P value	0.011*†			0.277*		

*** Using Kruskal-Wallis test.**

† Using Mann Whitney test: LED-Ramp compared to LED-Fast (P=0.989); LED-Ramp compared to Halogen (P=0.001), LED-Fast compared to Halogen (P=0.05).

 # Vibration: Using Compothixo plugger for composite condensation.

$ Conventional: Using hand plugger for composite condensation.

Another comparison found that the difference in the microleakage scores between the cervical walls and occlusal walls was highly significant regardless of the condensation techniques and light curing mode, P<0.001 (Table 4).

The microleakage scores of the cervical walls were compared between conventional and vibration techniques, in which the difference was highly significant (P<0.001). In comparison with the occlusal walls between the two condensation techniques, the difference was statistically non-significant (P=0.475) (Table 5).

Table 4: Microleakage scores of all cervical walls compared to that of all occlusal walls.

Microleakage score	Cervical (n=120)	Occlusal (n=120)
0	23	88
1	31	26
2	41	3
3	12	0
4	13	3
P value	< 0.001*	

*** Using Mann Whitney test.**

Table 5: Microleakage scores of the cervical walls compared to that of occlusal walls, by condensation method.

Microleakage score	Cervical		Occlusal	
	Conventional $ (n=60)	Vibration # (n=60)	Conventional (n=60)	Vibration (n=60)
0	0	23	45	43
1	17	14	15	11
2	30	11	0	3
3	7	5	0	0
4	6	7	0	3
P value	<0.001*		0.475*	

*** Using Mann Whitney test.**

 # Vibration: Using Compothixo plugger for composite condensation.

$ Conventional: Using hand plugger for composite condensation.

DISCUSSION

The longevity of the restoration is greatly affected by marginal seal integrity.[16] This integrity is affected by the microleakage that occurs due to polymerization shrinkage which is the main cause of composite restoration failure.[9] One way to minimize the polymerization shrinkage is to allow the flow of resin composite during setting by means of controlled polymerization.

This flow might be enhanced using vibration during composite placement such as using the Compothixo plugger to facilitate the material flow and adaptation to the walls of the cavity.

This study assessed the composite microleakage using two different condensation techniques

(Conventional and Vibration) for composite placement and using different light curing modes in an attempt to promote the longevity of the composite restorations. All cavities had the same dimensions to overcome the effect of configuration factor (C-factor).[27] All cavity preparations and restorations were performed by the same operator to surpass multiple operator's errors as some researches recommended. [25]

It is obvious from Table (1) that the placement of composite using vibration showed significantly lower microleakage scores when compared to conventional hand plugger condensation. This could be explained by the fact that vibration decreases the viscosity of the material and facilitates its flow within the prepared cavity with better adaptation.[22]

Regarding the effect of light curing mode and the two condensation methods, there were highly significant differences between LED ramp groups with the least scores in the vibration group (Table.2). This finding could be explained by the fact that pre-polymerization at lower light curing intensity followed by final cure at high power intensity leads to improved flow of molecules in the material, decreasing the polymerization shrinkage stress in a restoration.[28] Therefore, the LED-Ramp group was expected to produce better marginal integrity and sealing especially when used with vibration which also enhances the flow of material and better marginal adaptation.

No significant differences were found between LED-Fast and Conventional groups in both main condensation groups. This could be attributed to the fact that both LED-Fast and Conventional halogen light modes did not allow material flow during polymerization as in LED-Ramp mode.[26]

There was a significant difference in the microleakage score between the two types of condensation as the vibration method recorded significantly less leakage (Table 3). In the conventional group, there were no significant differences by using different curing modes. In the vibration method, no significant differences were found between LED-Ramp and LED-Fast mode (P=0.989). Also, there were significant differences between LED-Fast and Halogen (P=0.05) and highly significant differences between LED-Ramp and Halogen group (P=0.001). These results showed that vibration would result in better adaptation of the resin composite to the walls of the cavity as compared to the conventional hand plugger and ultimately producing less microleakage.

For all groups, microleakage scores of all cervical walls were significantly higher compared to that of all occlusal walls (P=0.001) as shown in Table (4). There were no differences in the score of occlusal walls leakage for conventional and vibration groups (P=0.475), while there were highly significant differences between two main groups regarding leakage of cervical walls (P=0.001) as seen in Table (5). These results could be due to the differences in the arrangement of the enamel rods between the cervical and coronal parts of the tooth. These observations agree with the previous studies[29-32] but disagree with other studies.[24-29,33,34] As in the current study the cervical walls were located in enamel while in the previous studies were located in dentin and marginal leakage at dentin was more than in enamel.[29,31] Also, these differences may be attributed to differences in placement techniques. Vibration technique, as reported in this study seems to promote cervical integrity.

CONCLUSION

Vibration technique in the insertion of composite decreases marginal leakage significantly as compared to conventional hand plugger. The decrease in marginal leakage is also affected by light curing modes used, especially with LED-Ramp mode produced less leakage compared to the LED-Fast and Halogen continuous modes.

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الخلاصة

الخلفية: يقلل الاهتزاز من لزوجة المادة الراتنجية، مما يجعلها تتدفق وتلتصق بسهولة مع جدران تجويف السن المحضر. استهدفت هذه الدراسة لمعرفة تاثير الاهتزاز واستخدام طرق تصلب الحشوات على التسرب المجهري للحشوات الراتنجية.

المواد والطريقة: تم إعداد تجاويف من الفئة الخامسة على السطح الشدقي لستين من الضواحك المقلوعة. تم تقسيم الأسنان عشوائيا إلى مجموعتين (ع = 30) وفقا لوضع الحشوة (الاهتزاز والطريقة التقليدية). ثم قسمت إلى ثلاث مجموعات فرعية (ع = 10) وفقًا لأنماط معالجة الضوء (أوضاع LED-Ramp وLED-Fast وHalogen). تم حفر التجويفات واستخدام اللاصق Single Bond Universal ثم ملئها بحشوة (Filtek® Z350).

في مجموعة الاهتزاز، تم وضع الحشوة باستخدام (Compothixo^{TM}, Kerr) وفي المجموعة التقليدية، تم وضعها باستخدام المدك اليدوي. كانت أوضاع تصلب الحشوة لجميع المجاميع هي (LED المستمرة والمنحدرة LED والهالوجين المستمرة على التوالي). تم وضع العينات في الماء المقطر عند 37 درجة مئوية لمدة سبعة أيام، ثم صبغت بطبقتين من طلاء الأظافر مع بقاء ملم واحد فقط حول الحشوة، تم غمر جميع

العينات في محلول الميثيلين الأزرق 2٪ لمدة ثلاث ساعات، ثم قطعت طولياً. تم تقييم التسرب المجهري باستخدام المجهر. تم تحليل المعطيات بواسطة اختبارات Kruskal-Wallis و Mann-Whitney U.

النتائج: أظهرت مجموعة الاهتزاز أقل تسرب مجهري (P=0.028). بينما في المجموعة التقليدية لم تكن هناك فروق باستخدام طرق علاج مختلفة (P=0.277). في مجموعة الاهتزاز لم توجد فروق (P=0.989) بين وضع (LED-Ramp وLED-Fast). بينما كانت هناك اختلافات كبيرة بين LED -Fast والهالوجين (P=0.05) وبين LED-Ramp ومجموعة الهالوجين (P = 0.001). التسرب المجهري من جهة عنق السن كانت أعلى من جهة الإطباق (P=0.001). تسرب الجدران الإطباقية للمجموعات التقليدية والاهتزاز لم تكن مختلفة (P= 0.475)، في حين أن هناك اختلافات كبيرة بينهما في جدران جهة عنق السن (P=0.001).

الاستنتاجات: وضع الحشوة بطريقة الاهتزاز مع وضع التصلب LED-Ramp قد يقلل من التسرب المجهري.