Microleakage of two resin composites by using different light curing systems

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Abstract:

This study was conducted to evaluate marginal microleakage of two resin composite (Glacier resin composite and Filtek P 60 resin composite) either cured with conventional light cure unit (Astralis 5) or light emitting diodes (LED) light cure unit (Radii). Forty class V cavities were prepared in 20 extracted second premolars, one buccaly and one palataly in each tooth. Each cavity was located 1mm coronal to cementoenamel junction and 1mm apical to it. The teeth were randomly divided into 4 groups, each group of five teeth (10 cavities): Group I was filled with Glacier resin composite and cured with LED curing unit. Group II filled with Glacier and cured with Astralis 5 curing unit. Group III filled with Filtek P60 resin composite and cured with LED curing unit. Group IV filled with Filtek P 60 and cured with Astralis curing unit. The teeth were stored in distilled water for seven days. Then the apices of the teeth were sealed with sticky wax and the teeth were covered with two layers of nail varnish except 1mm around the restoration. The teeth were immersed in 0.5% basic fuchsin dye for 24 hours at 37°C in the incubator and then were longitudinally sectioned in a buccolingual direction and the extent of dye penetration was recorded. The statistical analysis of the result revealed that the use of LED light cure unit, results in highly significant reduction in the microleakage occlusally and gingivally

Keywords:

Light curing units, microleakage, composite material

Introduction:

Even today, with all the advances in light cured composite and compomers, the major disadvantage of these materials is the development of shrinkage during polymerization [1].Conversion of the monomer molecule into a polymer network is accompanied by a closer packing of the molecules causing contraction in the composite. Such contraction creates mechanical stresses in the resin composite that can disrupt the marginal seal between the composite restoration and dentine or enamel [2, 3].

Polymerization shrinkage leads to some clinical problems, such as marginal fading, restoration fracture, solubility of the bonding system and marginal leakage [2].Methods used to reduce the effects of polymerization shrinkage include developing stronger bonding agents and non-shrinking composite, using bases and liners that act as shock absorbers and strategically placing composites in appropriate cavity configurations [4,5].In addition curing lights have been developed with varying outputs and curing cycles to

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speed up and/ or reduce marginal gaps [4,5].The technology utilized for curing lights ranges from conventional halogen bulbs to more exotic (and expensive)systems using lasers, plasma arc and (LED).

Halogen-based light curing units (LCUs) are the most commonly employed light- activation units in dentistry. Photocuring of dental composite by halogen-based LCUs is initiated by electromagnetic wavelengths between 400±500 nm; light in this length region activates camphoroquinone (CQ). The photoinitiator presence in the most light-activated resin composite restoratives, most effectively, the absorption spectrum of CQ lies in the 450-500nm wavelength ranges with peak absorption at 470nm[6].

The use of halogen curing light units to polymerize dental composite has several drawbacks despite their popularity. The halogen bulbs (which have a limited effective lifetime (about 40-100 hours) reflector and filter degrade overtime due to high operating temperatures and significant heat produce during cycles. The aforementioned will reduce the effectiveness of polymerization in composite restoratives [7].

LED light curing units (LCUs), developed to over come the problems inherent to halogen LCUs. This generation of curing units use light emitting diodes (LEDs) as sources of light. LED units are solid-state semiconductor (p-n junctions) devices that convert electrical energy directly to heat. The narrower spectral output of these blue LEDs of 440 to 480 nm fall within the CQ absorption spectrum. Hence require no filters to produce blue light and are resistant to shock and vibration. Cited advantages of LED lights include: **a**- cost-efficiency with a longer lasting source compared to halogen or other devices,(have life times of more than 10,000 hours)**b**- clinician friendliness with cordless features, **c**-battery operation with no bulb aging and no decrease in output as bulb ages, **d**-less heat production, and no fan necessary [7, 8, 9].

Mills et al.[10] have shown that the blue LED light curing system have the potential to polymerize dental composites without having the drawbacks of halogen light curing system. Nomura et al.[11] reported that dental resins cured with blue LED having a higher degree of polymerization and more stable three dimensional structure than those cured with halogen lamps.

This study evaluated the marginal leakage of two resin composites using different curing system: conventional light cure unit and light emitting diode (LED) cure unit.

Materials and methods:

I-Sample selection and Preparation:

Twenty extracted human second premolars stored in the distilled water at room temperature were used in this study. Only teeth that were free of caries and restorations and showed no evidence of white spots or cracks on buccal or lingual surfaces were selected. Forty standardized class V cavities (one on the buccal and one on the lingual surface of each tooth) were prepared with a high speed tungsten carbide fissure No.330 (Komet, Germany) using water as coolant. The cavosurface walls were finished with stainless steel fissure bur No. 53 (Komet.Germany) in the low speed handpiece. New bur for each 5 cavities was used. Preparation include an occlusal margin in enamel and cervical margin 1mm apical to the cemento-enamel junction the preparation was approximately 3mm wide, 2mm high and 2mm deep. In accordance with international guide lines a butt-joint finishing line was prepared in the present study for cavosurface line angles [12].

2-Sample Grouping:

The teeth were randomly divided into 4 groups .Each group consists of 5 teeth (10 cavities):-

Group I: Each cavity filled with Glacier resin composite and cured with LED light cure unit (Radii) for 25 second show in tables (1& 2).

Group II: Each cavity filled with Glacier resin composite and cured with conventional light cure unit (Astralis 5) for 40 second.

Group III: Each cavity filled with Filtek P 60 resin composite and cured with LED light cure unit (Radii) for 25 second.

Group IV: Each cavity filled with Filtek P 60 resin composite and cured with conventional light cure unit (Astralis 5) for 40 second.

Table (1): Technical profile of the materials evaluated

Materials/ (shade/ Lot#)	Manufacturer	Composition
Filtek P 60 A2/3TJ	3 M Dental product, USA	Bis-GMA,UDMA Bis-EMA Fillers:zirconia,Silica Filler volume:61
Glacier A2/030727	SDI,Australis	Multifunctional methacrylic ester (UDMA) Fillers: Silica/glass powder Filler volume:62

Table (2): Light curing units investigated

Light curing units	Intensity Mw/cm2	Time of curing (s)
Astralis 5	530	40 s
Radii (LED)	1400	25 s

3-Filling Technique:

Each group filled with resin composite of A3 shade, according to its manufacturer instructions. After etching, rinsing, adhesive application and curing, the composite resin was applied to the cavity by its applicator, and covered with celluloid strip. The composite materials investigated and the distance of the light cure tip from the composite (1mm via usage of the glass slide), were therefore standardized in this study. The specimens of four groups were stored for seven days in distilled water.

4- Dye Leakage Study:

The root apices were occluded with sticky wax, and the teeth were painted with two coats of acid resistant varnish to within 1mm of the margins of the restorations. The specimens were immersed in 0.5% basic fuchsine solution and stored for 24h at 37^{0} C. after that they were washed for one minute in running water and dried by air for 5 seconds. A diamond wheel cooled with water was used to section each tooth longitudinally through the center of the restorations. Each restoration was observed under stereomicroscope. The reading of the section (with higher dye penetration) of each restoration was recorded at different times by two trained evaluators. The average of the two measurements of the section of the restoration was considered for statistical analysis.

The degree of marginal leakage was evaluated using a standardized scoring system similar to that used by Munro et al.[13].A zero value was assigned where there was no evidence of microleakage, dye penetration up to half the cavity depth scored a value of 1. When the dye penetration was more than half of the cavity depth, a value of 2 was recorded, and when it has spread to involve the axial wall the microleakage was assigned a value of 3. Mean leakage scores for all groups were also calculated.

The analysis of variance (ANOVA) test was performed to determine if that there was a significant difference in microleakage among the four experimental groups, and then least significant difference (LSD) test was used for multiple comparisons between the four experimental groups.

Results:

The row scores of microleakage are presented in table (3) and (4), which represented the microleakage occurred in the different groups occlusally and gingivally.

Table (3): Scoring of microleakage (gingivally)*

Score	Group I		Group II		Group III		Group IV	
0	4	40%	3	30%	3	30%	1	10%
1	6	60%	3	30%	5	50%	3	30%
2	0	0%	3	30%	2	20%	5	50%
3	0	0%	1	10%	0	0%	1	10%
total	10	100%	10	100%	10	100%	10	100%

*** Mean: Group I=0.2 Group II =1.0 Group III = 0.82 Group IV = 1.5**

Table (4): Scoring of microleakage (gingivally)*

Score	Group I		Group II		Group III		Group IV	
0	4	40%	1	10%	2	20%	0	0%
1	5	50%	2	20%	5	50%	1	10%
2	1	10%	5	50%	3	30%	4	40%
3	0	0%	2	20%	0	0%	5	50%
total	10	100%	10	100%	100%	100%	10	100%

* Mean: Group I =0.52 Group II = 1.4 Group III = 1.0 Group IV = 2.2

The highest percentage occlusally with score 0 was found in group I (40%).While the highest percentage occlusally with score 3 was found on groups II (10%) and IV (10%).

Table (3) shows the dye penetration gingivally with score 3, for group II (20%), and for group IV (50%). While for group I and III, there was no specimen with score 3. The lowest mean score for dye penetration was found with group I, occlusally (0.2) and gingivally (0.521) as shown in tab. (3) and (4) respectively.

ANOVA revealed that there is a highly significant difference (P< 0.01) between the four groups and mean score of microleakage occlusally as shown in table (5).

Table (5): ANOVA test for dye penetration measurement of the occlusal margins.

Groups	No. of teeth	Mean of dye penetration(mm)	S.D	R	F	Sig.
I	10	0.2	0.194	0 – 0.5	6.417	**
II	10	1.0	0.812	0 – 2		
III	10	0.82	0.652	0 – 2		
IV	10	1.5	0.820	0 - 3		

S.D = stander deviation
R = range
** = (P < 0.01)

While gingivally it revealed that there is a very highly significant difference (P<0.001) as shown in table (6).

Table (6): AVOVA tset dye penetration measurement of the gingival margins.

Groups	No. of teeth	Mean of dye penetration(mm)	S.D	R	F	Sig.
I	10	0.521	0.453	0 – 1	12.388	***
II	10	1.4	0.661	0 – 2		
III	10	1.0	0.691	0 – 2		
IV	10	2.2	0.714	1 - 3		

S.D = stander deviation
R = range
** = (P < 0.01)

The least significant difference (LSD) test showed that there was occlusally a highly significant difference (P < 0.01) between group I and II, while gingivally a very highly significant difference (P < 0.001) was found, as it is illustrated in table (7).

Table (7): LSD test

Comparisons groups		Mean difference	Statistical significant
occ.	I vs. II	- .8000	**
	I vs. III	- .06200	*
	III vs. IV	- .06800	*
	II vs. IV	- .5000	*
ging.	I vs. II	- .8790	***
	I vs. III	- .4790	*
	III vs. IV	- 1.200	***
	II vs. IV	- .800	**

By comparing group III and IV a significant difference (P<0.05) was found occlusally, and a very highly significant difference (P < 0.001) was found gingivally.

A significant difference (P < 0.05) was shown between group I and III occlusally and gingivally, also when comparing group II and IV a significant difference (P < 0.05)was found occlusally and a highly significant difference
(P < 0.01) was found gingivally

Discussion:

There are no accepted scientific methods to correlate in vitro leakage results to clinical findings, results of in vitro studies are often presumed to be more negative than in vivo studies, suggesting that leakage found in vitro should be regarded as theoretical maximum amount of leakage that may not be occurred in vivo [14].

Denehy et al.[15] have found that light intensity measurements decreased with increasing distance from curing tip, and the reduced light intensity will result in a softer bottom of a 2-mm thick specimen. Therefore, the distance of light cure tip from composite (1mm via usage of glass slide) was standardized in this study. Shade A3 was selected to minimize the effects of colorants on light polymerization and 2mm thick composite specimens were evaluated as they gave uniform and maximum polymerization [16].

According to the results of this study, resin composite cured with LED LCUs in group I and III showed the lowest mean of dye penetration either occlussaly or gingivally, in comparing with resin composite cured with conventional LCUs in group II and IV.

Optimization of the physical properties of light- activated dental materials is achieved when LCUs deliver enough light at the appropriate wavelength of the respective photoinitiator systems in resin based composite. Unlike halogen LCUs, LED emission spectrum is narrow and falls within the absorption spectrum of(CQ).Light in LED LCUs is not generated by a thermal process but by a well-defined relaxation of exited electron, is produce only visible light in 440 to 480nm with peak wave length range 460nm,and produce less heat result in less post polymerization shrinkage and thermal contraction, while halogen based lamps produce light by incandescence, whereby, a filament is heated, causing excitation of atoms over a wide rang spectrum, and more heat production [17, 18].

Yap et al.[19] found that, the composite continued to shrink after removing the light sources, and the shrinkage observed after removal of the curing light may be attributed to the progressive cross-linking reaction that occurs following light polymerization initiation and thermal contraction due to loss of radiant heat.

In 2003 Yap et al.[20] conducted a study to compare thermal emission by different light curing units, he found that LED LCUs produce significantly less heat than halogen units. Moreover, in LED units, the light output power is gradually increases within the first 5 seconds, starting irradiation at reduced light intensity allows more time for composite to flow and this minimizes polymerization stress in the restoration and improves the marginal seal of the restoration.

Group I with microfilled hybride composite showed the lowest leakage scores. According to its manufacturers Glacier resin composite has ability to utilize longer resin chains with fewer monomer links to reduce shrinkage. Less links equate to less shrinkage. Contraction stress is not only influenced by shrinkage strain but also depends on the modulus of the materials. In accordance with their low module, microfilled hybrid was found to produce lower shrinkage stress and better margin quality [21, 22].

The packable resin composite cured with conventional LCUs in group IV showed the highest leakage scores. These high scores may be attributed to a high elasticity modulus of the composite that can cause more strain in the interface during polymerization. In addition the filler particle technology of the Filtek P 60 composite could translate into increased post- gel liner shrinkage stress directed at the margin [22]. Stress arising from post- gel polymerization shrinkage may produce defects in the composite-tooth bond leading to bond failure and, consequently, microleakage. This result coincide with a study conducted by Coelho et al.[23], who showed that a high volumetric shrinkage occurred with Filtek P60 composite in comparing with other type resin composite.

The four groups showed relatively greater leakage at the gingival margin than the occlusal margin. The most likely cause for this phenomenon is the polymerization contraction of composite which manifested towards the stronger enamel-composite interface. This is due to that, adhesion to dentin is more complicated because of the composition and histological structure of the substrate.

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