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Effect of Two Light-emitting Diode (LED) and One Halogen Curing Light on the Microleakage of Class V Flowable Composite Restorations

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Abstract

Aim: The disadvantages of light cured composite resin materials with respect to microleakage are predominantly a result of polymerization shrinkage upon curing. It has been shown curing methods play a significant role in polymerization shrinkage of light-cured composite resins. The purpose of this study was to investigate the effect of light-emitting diode (LED) light curing units (LCUs) compared with a halogen LCU on microleakage of three different flowable composites using self-etch adhesives.

Methods and Materials: A total of 63 extracted human premolars were prepared with standardized Class V cavity preparations on the buccal and lingual surfaces of each tooth. The occusal margin of the cavities was located on the enamel and the gingival margin was on dentin. Teeth were randomly assigned to three groups of 21 teeth each as follows: Group 1: Adper Prompt L-Pop + Filtek Flow (3M ESPE); Group 2: AdheSE + Tetric Flow (Ivoclar, Vivadent); and Group 3: Clearfil Protect Bond + Clearfil Protect Liner F (Kuraray Medical Inc.). All the groups were subdivided into three groups according to the curing lights used (n=7). Two LED LCUs, Elipar FreeLight and Elipar FreeLight 2 (3M ESPE), and one halogen-based LCU, Hilux Expert (Benlioglu), were used. All teeth were then immersed in 0.5% basic fuchsin dye solution for 24 hours after thermocycling (500 cycles; between 5ºC to 55ºC). The teeth then were longitudinally sectioned and observed under a stereomicroscope (40X magnification) by two examiners. The degree of dye penetration was recorded separately for enamel and dentin. Data were analyzed with the Kruskal-Wallis and Mann-Whitney tests with the Bonferroni correction.

Results: No statistically significant differences in microleakage were observed between groups either on enamel or dentin ($p>0.05$).

Conclusion: With the limitation of this *in vitro* study, the differences in microleakage between LCUs used were not statistically significantly different. Elipar Free Light 2 reduces curing time which can be considered as an advantage.

Keywords: Light-emitting diode, LED, microleakage, flowable composite, self-etch adhesive

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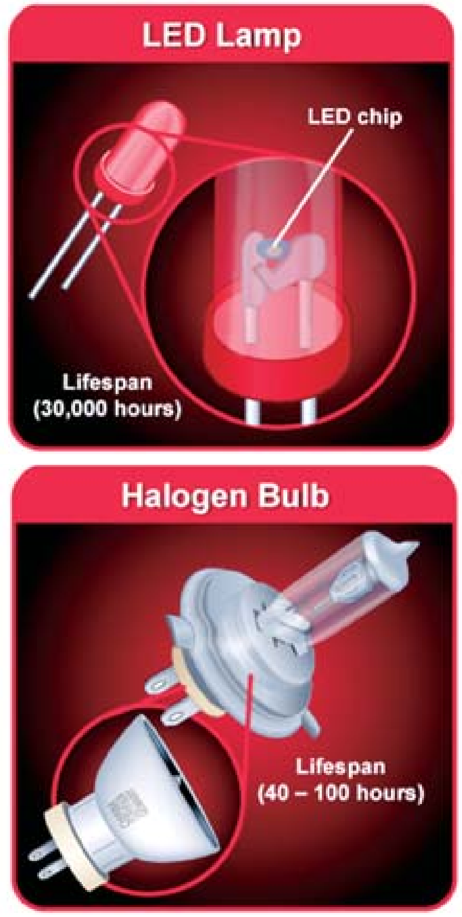
Introduction

Halogen light curing units (LCUs) have been used for many years, however, they have some drawbacks. For instance, their bulbs have a limited life span (40–100 hours); as the performance of the bulb progressively diminishes, a decrease in favorable properties of composite materials occurs.[1,2] In addition the vitality of the pulp can be affected by rising temperatures during polymerization.[3] LCUs also require approximately 40 seconds of exposure time for adequate polymerization of the composite resin.[4]

Innovative light-emitting diode (LED) technology has been improved for light curing dental materials in order to overcome the inadequacies of the halogen LCU's.[5] LED LCU's are inexpensive, low voltage devices which have a long life expectancy. They are very compact and can be designed to emit specific light waves. The units have better resistance to shock and vibration, and they are also portable and safe.[5,6] Although they have lower light emission, LEDs have the ability to cure like other light sources or slightly less.[7] In addition, the temperature increase is significantly less and does not pose a threat to pulpal tissue.[8,9] Saving time during the light curing process is one of the most important aspects to clinicians who use the incremental filling technique.[10]

Self-etching primers designed to simplify and shorten bonding procedures were developed recently.[11] They enable composite to enamel bonding without treatment of a separate phosphoric acid gel for etching of the enamel surface.[11-15]

Early flowable composite formulations were characterized by Bayne and others.[16] They are purported to offer higher flow, better adaptation to the internal cavity wall, easier insertion,



and greater elasticity than previously available products.[17] One of the indications of the flowable composites is the restoration of Class V defects.[18] Composites present an inherent disadvantage consisting of polymerization shrinkage during setting.[19-21] This shrinkage depends on the:

- configuration of the restoration (C factor),
- type and shade of the composite resin,
- viscoelastic properties of the dentin bonding system used in the adhesive procedure,
- the restorative technique and the light curing protocol.[10,22-29]

Polymerization shrinkage can result in gap formation between the cavity walls and composite resin.[30,31] Gap formation contributes to microleakage, permitting the passage of bacteria and oral fluids from the oral cavity.[32] Post operative sensitivity, pulpal inflammation, and secondary caries may occur because of microleakage.[33]

Several studies have reported ways to reduce microleakage in Class V lesions.[32,34,35] Although curing lights and bonding materials are improving rapidly, there is no currently available technique that can prevent gap formation especially at either the cementum or dentin-restoration junctions.[32,35,36]

The aim of this study was to evaluate the effects of LED LCU's compared to a halogen LCU on the microleakage of three different flowable composites with self-etch adhesives.

Methods and Materials

A total of 63 freshly extracted, caries free, human premolars without cracks or previous restorations were selected for the study. Calculi and residual soft tissue were carefully removed, and the teeth were stored at room temperature (23ºC - 27ºC) in distilled water within one month after extraction.

Standard Class V cavity preparations (mesio-distal width of 3 mm, occluso-gingival length of 2 mm, and a depth of 1.5 mm) were prepared on buccal and lingual surfaces with a high-

speed hand-piece with air-water spray and a #1090 diamond fissure bur (Diatech Dental AG, Heerbrugg Switzerland). New burs were used after every four preparations. Each preparation was designed with the occlusal margin in enamel and the cervical margin in dentin.

The teeth were divided into three groups according to the flowable composite used to restore the teeth (Table1) (Figure1).

Each group was subdivided into three subgroups for three LCU's (n=7) (Table 2) (Figure 2).

Table 3 shows the experimental groups in the study.

Group I: Adper Prompt L-Pop self-etch adhesive was applied with an active bluster and rubbed for 15 seconds then gently blown with air and light cured as follows:

- (Group Ia): Ten seconds with an Elipar Free Light followed by an application of Filtek Flow

Table 1. Materials and their self-etch adhesives used in this study.

Group	Product		Batch #	Manufacturer
1	Adhesive System	Adper Prompt L-Pop	201130	3M ESPE Dental Products, St. Paul, MN, USA
	Flowable Composite	Filtek Flow	3700A3	
2	Adhesive System	AdheSE	F22511	Ivoclar Vivadent AG, Schaan, Liechtenstein
	Flowable Composite	Tetric Flow	G05181	
3	Adhesive System	Protect Bond	61118	Kuraray Medical Inc., Sakazu,Kurashiki, Japan
	Flowable Composite	Protect Liner F	0049	

Figure 1. Flowable composites and their self-etch adhesives used in this study.

Table 2. Light curing units (LCUs) used in this study.

LCU	Type	Manufacturer	Intensity (approx.)
Elipar Free Light	LED	3M ESPE Dental Products, St. Paul, MN, USA	400mW/cm2
Elipar Free Light 2	LED	3M ESPE Dental Products, St. Paul, MN, USA	1000mW/cm2
Hilux Expert	Halogen	Benlioğlu Dental, Bülbülderesi Cad.8'A, Ankara, Turkey	500mW/cm2

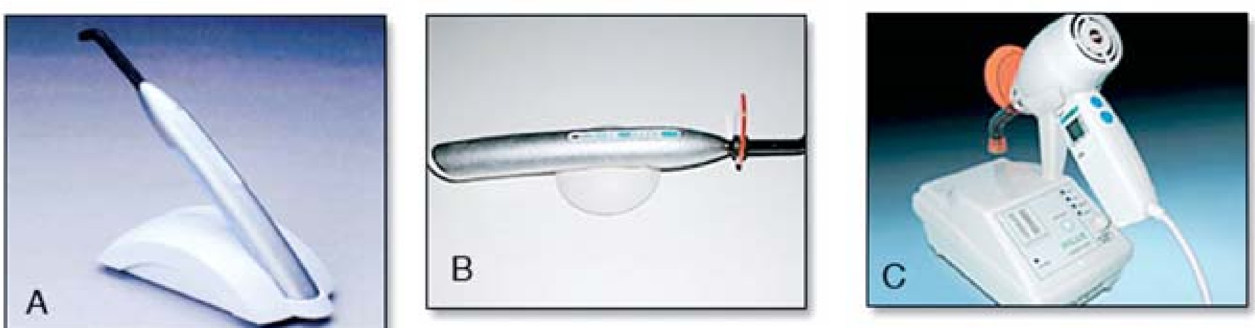


Figure 2. Light curing units used in this study. **A**. Elipar Free Light **B.** Elipar Free Light 2 **C.** Hilux Expert

Table 3. Experimental Groups.

Groups		Application Procedures
Group I	Group Ia	Adper Prompt L-Pop + Filtek Flow + Elipar Free Light
	Group Ib	Adper Prompt L-Pop + Filtek Flow + Elipar Free Light 2
	Group Ic	Adper Prompt L-Pop + Filtek Flow + Hilux Expert
Group II	Group IIa	AdheSE + Tetric Flow + Elipar Free Light
	Group IIb	AdheSE + Tetric Flow + Elipar Free Light 2
	Group IIc	AdheSE + Tetric Flow + Hilux Expert
Group III	Group IIIa	Protect Bond + Protect Liner F + Elipar Free Light
	Group IIIb	Protect Bond + Protect Liner F + Elipar Free Light 2
	Group IIIc	Protect Bond + Protect Liner F + Hilux Expert

and cured for another 40 seconds with the same light

- (Group Ib): Five seconds with an Elipar Free Light 2 followed by an application of Filtek Flow and cured for another 20 seconds with the same light
- (Group Ic): Ten seconds with an Hilux Expert followed by an application of Filtek Flow and cured for another 40 seconds with the same light

Group II: The primer component of AdheSE self-etch adhesive was applied for 30 seconds and gently air dried followed by the bonding agent and light cured as follows:

- (Group IIa): Ten seconds using the Elipar Free Light
- (Group IIc): Ten seconds using the Hilux Expert
- (Group IIb): Five seconds using the Elipar Free Light 2

Tetric Flow was then applied and cured as follows:

- (Group IIa): 40 seconds using the Elipar Free Light
- (Group IIc): 40 seconds using the Hilux Expert
- (Group IIb): 20 seconds using the Elipar Free Light 2.

Group III: Protect Bond, the primer, was applied for 20 seconds, gently air dried, then the bonding resin was applied gently air dried and light cured as follows:

- (Group IIIa): Ten seconds using the Elipar Free Light
- (Group IIIb): Five seconds using the Elipar Free Light 2
- (Group IIIc): Ten seconds using the Hilux Expert

Protect Liner F was then applied and cured as follows:

- (Group IIIa): 40 seconds using the Elipar Free Light
- (Group IIIb): 20 seconds for Elipar Free Light 2
- (Group IIIc): 40 seconds using the Hilux Expert

The restorative materials were placed using a single increment since the depths were less than 2 mm. The LCU's were placed to the buccal or lingual surfaces at close range (0-1 mm). All preparation of teeth, restorations, and finishing were performed by one operator. After storage in water at 37ºC for 24 hours, the restorations were finished with fine-grit finishing diamond burs (Diatech Dental AG, Heerbrugg Switzerland) and polished with a graded series of Sof-Lex XT Polishing Discs (3M ESPE, St. Paul, MN, USA).

The specimens were then thermocycled 500 times each at 5°C and 55°C. The specimens were subsequently sealed with a composite resin (TPH Spectrum, Dentsply de Tray, Constanz, Germany) at the root apices, and two coats of fingernail varnish were applied on the tooth 1.5 mm short of the margins to be exposed to dye. The restorations were then immersed in 0.5%

aqueous basic fuchsin dye for 24 hours. They subsequently were rinsed under running water to remove dye and dried at room temperature. The specimens were sectioned longitudinally through the center of the restorations with a diamond saw (Isomed Buehler, Ltd, Lake Bluff, IL, USA). Dye penetration was quantified for the enamel and dentin margins separately. The degree of dye penetration was then graded at 40X original magnification with a stereomicroscope (Leica MS5 Singapore, Singapore) using the following scale (a 0-3 scoring system was used to describe the severity of infiltration):[37]

0 = No dye penetration

1 = Dye penetration up to one-third of the cavity wall

2 = Dye penetration more than one-third, but less than two–thirds of the cavity wall

3 = Dye penetration more than two-thirds, or to the full extent of the cavity wall

The linear microleakage scores for the groups were analyzed using Kruskal-Wallis and Mann-Whitney U tests with the Bonferroni correction for pair wise comparisons at a significance level of $p<0.05$.

Table 4 shows the distribution of dye penetration scores at the enamel and dentin margins in all groups.

Tetric Flow, Protect Liner F, and Filtek Flow exhibited no statistically significant differences in values between the LCU's on enamel and dentin interfaces ($p>0.05$). In the Hilux Expert and Elipar Free Light 2 LCU groups there were no statistically significant differences between flowable composites on either enamel or dentin interfaces ($p>0.05$).

More microleakage was found at the dentin interface when the Filtek Flow was cured with the Elipar Free Light. However, when the Bonferroni correction for pair wise comparison was used, no statistically significant differences between flowable composites were found in the Elipar Free Light groups ($p>0.05$).

Comparing the microleakage scores between enamel and dentin margins with each restorative material using different LCU's, there was a slight increase in leakage at the dentin margins but this was not statistically significant ($p>0.05$).

Discussion

Light cured composite resin materials have several advantages such as control of the contour during placement of the restoration, better color stability, and a more complete polymerization compared to chemically activated materials.[38] An inherent disadvantage of these materials is they contract during light polymerization.[39] Microleakage is a phenomenon of the diffusion of organic or inorganic substances into a tooth through the interface between the restorative material and the tooth structure.[40] Microleakage may result from many factors, such as the extent of the marginal gap, polymerization shrinkage of materials used, the degradation of the particular bonding or restorative material used, dissolution of linear or smear layers, and varying coefficients of thermal expansion for restorations.[41-43]

A variety of curing lights are available for the photo polymerization of light cured dental resins. The most common approach is the conventional halogen LCU. It has been shown that halogen curing light deliver an inadequate light intensity.[44] LED technology may overcome some of the drawbacks of halogen LCU's; consequently, LED technology has a promising future.[44] It has been reported significantly less microleakage occurred at the dentin/cementum interface when restorations were cured with an LED unit compared to curing with the standard halogen LCU, however, no significant difference in microleakage was found between LCU's at the enamel interface.[45]

In this study there were no significant differences between LED and halogen LCU's both in enamel and dentin. In an other study, there was also no significant difference in microleakage reported between LED LCUs compared with halogen LCU at enamel margins, however, at dentin margins only the Elipar Freelight (soft start) was found to significantly reduce microleakage.[45] In order to prevent microleakage it is clear all margins must be kept in enamel. However, root caries, abfraction, and abrasion lesions have their margins in dentin or cementum.[32] Hence, the

Table 4. Microleakage and mean leakage scores.

Groups		Leakage Scores				
		0	1	2	3	Mean
Group Ia	Enamel	10	4	0	0	0.2857
	Dentin	0	8	6	0	1.4286
Group Ib	Enamel	14	0	0	0	0.00
	Dentin	6	4	2	2	1.00
Group Ic	Enamel	12	2	0	0	0.1429
	Dentin	6	4	0	4	1.1429
Group IIa	Enamel	14	0	0	0	0.00
	Dentin	2	12	0	0	0.8571
Group IIb	Enamel	14	0	0	0	0.00
	Dentin	10	2	2	0	0.4286
Group IIc	Enamel	10	2	2	0	0.4286
	Dentin	8	6	0	0	0.4286
Group IIIa	Enamel	10	4	0	0	0.2857
	Dentin	2	12	0	0	0.8571
Group IIIb	Enamel	10	4	0	0	0.2857
	Dentin	6	8	0	0	0.5714
Group IIIc	Enamel	12	2	0	0	0.1429
	Dentin	12	2	0	0	0.1429

occlusal margins of the cavities were placed on the enamel and the gingival margins on dentin in this study.

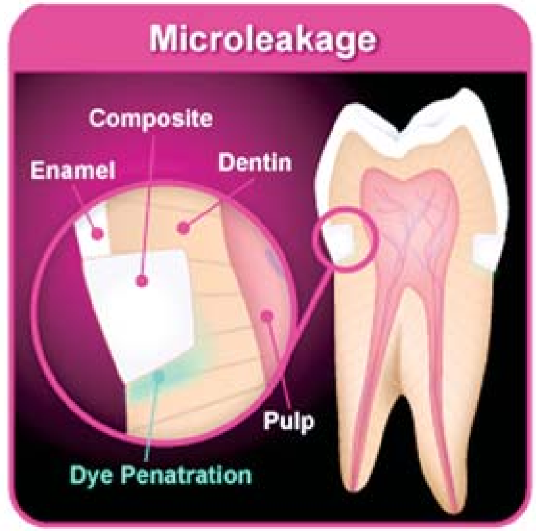
Self-etch adhesives have recently become available and combine the functions of primer and adhesive components which has eliminated the need for separate acid etch and rinsing steps.[46] One disadvantage is self-etch adhesives are not able to etch the enamel as deeply as phosphoric acid.[47] Many dentists prefer to etch the enamel to obtain retention for self-etch adhesives even without clinical evidence of efficacy.[48] In this study, the enamel was not etched with phosphoric acid. Despite significant improvements in dentin bonding systems, no system is currently able to completely prevent the formation of contraction gaps, especially at the cementum/dentin restoration junction.[35,36]

A new class of "flowable composites" has been marketed since 1996. Their flow characteristics differ from hybrid composites allowing them to be easily inserted and adapted to cavity surfaces using an injection technique.[16,49] Estafan and Estafan have reported flowable composites demonstrate resistance to microleakage in both enamel and cementum/dentin margins similar to TPH hybrid composite.[50]

Restorative materials, when tested *in vitro*, fail to simulate the dynamic intra thermal changes induced by routine eating and drinking. Thermocycling is often employed in laboratory experiments to simulate stresses in the oral cavity. The absence of an outward flow of dentinal fluid and a completely altered dentinal surface due to extraction lead to a poor correlation between *in vivo* and *in vitro* conditions.[51] Fuchsin dye penetration was chosen for this study because it provided a simple, relatively cheap, quantitative, and comparable method of evaluating the various composite systems.[52]

Conclusion

It may be concluded that microleakage still a reality with the adhesive systems, flowable composites, and LCU's used in this study. Two LED LCU's did not eliminate microleakage and showed similar microleakage with a halogen LCU. The Elipar Free Light 2 has a higher intensity resulting in a reduction of curing time. Saving time is an important issue for busy clinicians especially when using the incremental filling technique which requires repeated curing of each increment after insertion.



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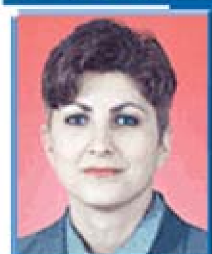

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