ORIGINAL RESEARCH

Effects of Different Curing Lights on Microleakage in Resin-Based Composite Restorations

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ABSTRACT

Introduction: The aim of the study was to investigate and compare light-emitting diodes (LED) with the conventional halogen light-curing unit to see the effect of different curings on microleakage in resin-based composite restorations and to observe the degree of microleakage occurring in enamel and dentine.

Materials and Methods: A total of 60 human mandibular teeth were used for the study. To ensure no dye reached the cavities through the pulp chamber and the dentinal tubules, the apical foramina were sealed with Dyract AP composite. Class V cylindrical cavities were prepared on the facial surfaces of the teeth using fissure carbide bur (SSW FG 560). The cavities were prepared in enamel and dentine at the cement-enamel junction, 1.5 mm deep and 3 mm in diameter. The coronal half was in the enamel, and the gingival half in the dentine. The cavities were treated with 35% phosphoric acid for 20 s and then rinsed with water for 15 s. Bonding agent was applied to enamel and dentine. The cavities were randomly divided into two groups of 30 each. Each cavity was filled with Esthet-X and cured. The cavities in the first group were exposed to halogen light, and the second group was exposed to LED light unit for 40 s each. The teeth from both the groups were stored in physiological saline (0.5 g/100 ml, Nirlife) separately for 24 h at 37°C and were thermocycled in a 0.5% basic fuchsin solution. Teeth were sectioned and examined under ×50 magnifications for dye penetration. Data were analyzed using Chi-square and Mann–Whitney U-tests.

Results: There was a significant association (P = 0.572) between dye penetration scores and curing light for dentine, The values revealed that the amount of microleakage was more for halogen light compared to LED light. These values were significant at the dentine level (P = 0.006).

Conclusions: From the present study, we can conclude that LED-based light-curing unit produced significantly less microleakage in enamel as well as dentin and halogen-based light-curing unit showed greater microleakage value in dentin.

Keywords: Dentin, Enamel, Halogen light, Light-emitting diodes, Microleakage.

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INTRODUCTION

The technology in dental restorative materials has evolved tremendously over the past few decades. The first resin composites way back in the 1970s were cured by ultraviolet lights; however, today, ultraviolet light has been replaced with visible light activating systems because of some serious drawbacks such as warm-up period of the apparatus, a limited depth of cure, and UV radiation exposure which may cause corneal damage.[1]

Light-cured composites have become universal in modern clinical dentistry. They have revolutionized the practice of dentistry by maximizing working time and by reducing setting time. Curing lights have been developed with varying outputs and curing cycles to reduce polymerization shrinkage in the restorations.[2,3] The technology utilized for curing lights ranges from conventional halogen bulbs to more exotic systems using lasers, plasma arc, and light-emitting diodes (LEDs). Adequate polymerization of light activated composites is important not only to ensure optimum mechanical properties but also to ensure that clinical problems do not arise due to the cytotoxicity of inadequately polymerized material.

To overcome the several drawbacks of halogen-curing light units which generate more heat thereby degrading bulbs over time,[4] blue LED light-curing units have been developed. LEDs have a lifetime of more than 10,000 h without significant degradation of light flux over time.[3] Instead of using a hot filament, LED uses a junction of doped semiconductors (p-n junctions) to generate light and hence requires no filters to reduce shock and vibration.[5] The spectral output of gallium nitrate blue LED falls conveniently within the absorption spectrum of the camphorquinone photoinitiator (400 nm–500 nm). Due to their superior conversion rate as well as optimum spectral emission, these small battery powered and handy devices are most likely to shape the next generation of curing lights.[6] The aim of this study was to investigate and compare LEDs with the conventional halogen bulb light-curing unit to see the effect of different curings on microleakage in resin-based composite restorations, with the objectives to observe the degree of microleakage occurring in enamel and dentine in composite resin restorations cured with LED light-curing unit and halogen light-curing unit.

MATERIALS AND METHODS

A total of 60 human mandibular single-rooted premolars, extracted for orthodontic purpose, were used for the study. The teeth were free of caries and cracks. After extraction, the teeth were cleaned with flour of pumice and stored in physiological saline containing a few crystals of thymol for <2 months.

Apical Tooth Preparation

To ensure no dye reached the cavities through the pulp chamber and the dentinal tubules, the apical foramina were sealed. 1 mm of root apices was cut off with a carborundum disc, and cavity was prepared at the cut root apices with an inverted cone carbide bur; the cavity was etched, bonded, and restored with Dyract AP composite.

Cervical Tooth Preparation

Class V cylindrical cavities were prepared on the facial surfaces of the teeth using fissure carbide bur (SSW FG 560) at high speed with water cooling. The cavities were prepared in enamel and dentine at the cement-enamel junction, 1.5 mm deep and 3 mm in diameter. The coronal half was in the enamel and the gingival half in the dentine. Standardization of the cavity was done by a mark on the bur for depth and by placing a sticker with a 3 mm punched hole. The hole on the sticker was punched with the help of rubber dam punch. The cavosurface angle was kept 90°. The bur was replaced after every six cavity preparations. The cavities were treated with 35% phosphoric acid for 20 s and then rinsed with water for 15 s. Ample amount of Prime and Bond NT was applied with a disposable brush to enamel and dentine and left undisturbed for 20 s. The excess bonding agent was removed with the air syringe for <5 s and then cured for 20 s. The cavities were randomly divided into two groups of 30 each. Each cavity was then filled with Esthet-X in three increments. Each increment was cured separately. Restorations were contoured with finishing diamond bur at high speed using air and water. The cavities in the first group were exposed to halogen light for 40 s in a continuous mode. The cavities in the second group were exposed to LED light unit for 40 s in standard mode.

The entire tooth was coated with nail varnish, except for the restoration and 1mm around it. The teeth from both the groups were stored in physiological saline (0.5 g/100 ml, Nirlife) separately for 24 h at 37°C. The teeth were thermocycled in a 0.5% basic fuchsin solution for 500 complete cycles between 8°C and 50°C with a dwell time of 15 s. The teeth were then removed from the thermocycling machine and nail varnish removed with flour of pumice. The teeth were sectioned under running water using a diamond disc cutter. The sections were examined under ×50 magnifications for dye penetration.

The degree of leakage on both the enamel and dentine margins was evaluated as follows.

0 = No dye penetration
1 = Penetration of the dye to less than a third from the margin
2 = Penetration of the dye to up to two third from the margin
3 = Penetration of dye up to the floor
4 = Dye along the floor of the cavity.

The number of restorations exhibiting each degree of leakage was recorded per light source and summarized in a two-way contingency table of observed frequency. To test for significant differences, a Chi-square test was done. Non-parametric Mann–Whitney U-test was used to test for difference between the average scores of the two lights.

RESULTS

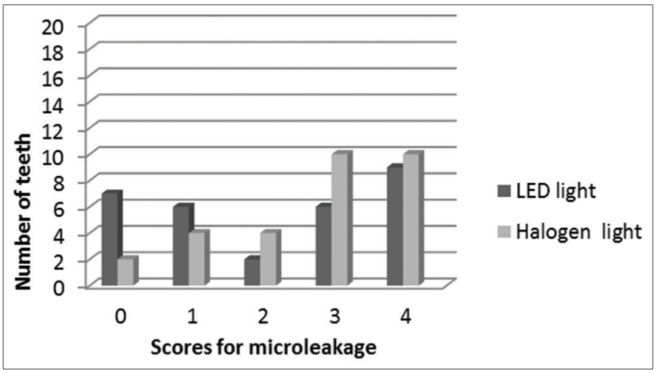
Chi-square test revealed that there was a significant association (P = 0.572) between dye penetration scores and curing light for dentine [Graph 1]; however, the values were non-significant for enamel [Graph 2].

Tables 1 and 2 demonstrate the mean values for dye penetration. The values revealed that the amount of microleakage was more for halogen light compared to LED light. These values were significant at the dentine level (P = 0.006).

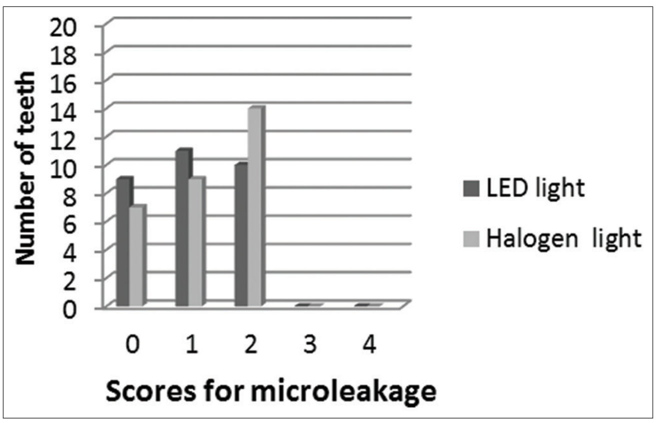
DISCUSSION

Light curing with some high-intensity lights compared with halogen lights may result in higher microleakage values.[6] The present study was conducted to evaluate microleakage values in Class V cavities restored with a microhybride resin-based composite (Esthet X) light cured with LED-curing light and halogen-curing light.

Our study results showed less microleakage values using the LED light-curing unit compared to the halogen light-curing unit. The mean values for microleakage were significantly less at the dentine level (P = 0.006). The outcome of our study corroborates the findings of other studies conducted by Oberholzer *et al*.[7] and Guo *et al*.[8] Their study reports on microleakage revealed better marginal seal of those teeth exposed to LED-curing light compared to halogen-curing light.[8]



Graph 1: Counts of dentine dye penetration scores for the curing lights. The Pearson Chi-square test revealed that there was a significant association between curing lights and dye penetration (P = 0.0298). Chi-square value = 4.9, df = 4, P = 0.0298 significant



Graph 2: Counts of enamel dye penetration scores for the curing lights. The Pearson Chi-square test revealed that there was an association between curing lights and dye penetration, but it was non-significant. Chi-square value = 1.11, df = 2, P = 0.572 NS

This similarity of results can also be explained by the fact that light produced by LED is situated in a narrow band wavelength (450–490 nm), which corresponds to canphoroquinone maximum absorption peak (470 nm), the main photoinitiator for the polymerization of composite resins. This light is formed by very close and highly energized colors because the blue color has more energy than other wavelengths, and it produces greater polymerization efficiency even with lower power density.[9] LED devices have less power in the first 10 s of photoactivation, whereas halogen equipments have continuous light. This initial low power density can reduce polymerization reaction speed, extending the pre-gel phase, and allowing for polymeric chains to rearrange. This would reduce post-gel shrinkage.[10] In the present study, we observed less microleakage at enamel margin compared to that of dentine. A possible explanation for this difference in the results obtained for the enamel and dentine side is that the physical properties of enamel and dentine differ greatly. Bonding to dentine is much more difficult to obtain due to the presence of dentinal tubules, which differ at different levels of the tooth, its vitality and its low mineral, and high organic and high water content compared to enamel. Thus, if a material shrinks due to light exposure, it is more likely to cause marginal gaps at the dentine side than at the enamel side.[11]

Contrary to the findings of the current results, a study conducted by Tielemans *et al*.[12] comparing the microleakage of composite filling cured with halogen bulb, LED and argon ion laser found more microleakage values when composites were cured with LED than

Table 1: Mean values for enamel dye penetration scores for the two lights. Mann–Whitney U test revealed that there was a difference in mean (SD) between LED and halogen light, but the results were NS

Group	*n*	Enamel dye penetration	Mann–Whitney U-test Z-value	*P*
		Mean±SD		
LED light	30	1.0333±0.80872	0.98	0.33 NS
Halogen light	30	1.2333±0.81720		

SD: Standard deviation, LED: Light-emitting diodes, NS: Nonsignificant

Table 2: Mean values for dentine dye penetration for the two lights. Mann–Whitney U-test revealed that there was a significant (sig) difference (P=0.006) in mean (SD) between LED and halogen light

Group	*n*	Dentine dye penetration	Mann–Whitney U-test Z-value	*P*
		Mean±SD		
LED light	30	2.133±1.613	2.773	0.006 Sig.
Halogen light	30	3.133±1.257		

SD: Standard deviation, LED: Light-emitting diodes with halogen light and argon ion laser. Similarly, Dunn and Bush[13] studied the adequacy of LED light-curing units and concluded that halogen lights produce significantly harder top and bottom resin-based composite surfaces than did LED lights.

Yazici *et al*.[14] and others evaluated the influence of different light-curing units and found that none of the restorations showed leakage on enamel margins. However, on dentine margins, no significant difference was observed when composite resin was polymerized with halogen light. For Esthet X Flow, no significant difference was observed between curing units. Attar and Korkmaz[15] did a similar study, i.e., they evaluated microleakage in enamel using LED and halogen curing light and found no difference in microleakage value between any of the curing devices used in their study. The results agree with Nalcaci and Ulusoy[16] who also found that there was no statistically significant difference in microleakage of pit and fissure sealant polymerized using various curing techniques.

According to Sadeghi[17] in their *in vitro* study on microleakage among various light-curing units, the choice of light curing technology has no significant effect on the amount of microleakage observed. The possible reasons for such contradictory results could be that different light curing units need not necessarily be the only contributing factor for microleakage in composite resins. Microleakage is also dependent on the particle size of composite resins, the type of curing mode, type and thickness of the adhesive resins used and filler/weight content of material used.[7,14,18-21]

One of the important factors considered in determining the success of a restoration is microleakage reduction. In this study, microleakage was less seen in the restorations which were cured with LED light-curing unit. Based on the results of this study, and within the limits of experimental conditions, it can be inferred that the LED light-curing unit produce significantly less microleakage in enamel and dentine as compared to halogen light-curing unit in resin-based composite restorations.

CONCLUSION

The demerits of light-cured composite resins with respect to microleakage are predominantly because of polymerization shrinkage on curing. Several approaches have been introduced to overcome the problem of polymerization shrinkage. It has been shown that curing lights of varying outputs and curing cycle play an important role in polymerization shrinkage of light-cured composite resins.

Inadequate polymerization of resin-based composites has been associated with microleakage which results in inferior physical properties, retention failure, higher solubility, and adverse pulpal responses to unpolymerized monomers.

From the present study, we can conclude that LED-based light-curing unit produced significantly less microleakage in enamel as well as dentin and halogen-based light-curing unit show greater microleakage value in dentin; however, further clinical trials are needed to confirm the above findings.

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