



Curing depth of pit and fissure sealants with use of light emitting diode (LED) at different distances

Profundidad de curado de selladores de fosetas y fisuras utilizando luz emitida por diodos (LED) a diferentes distancias

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ABSTRACT

In the process of caries prevention, placement of pit and fissure sealants is a low-priced, effective and safe procedure. Presently, clinical operators prefer LED lamps. In pediatric dentistry, certain complications might arise such as lack of patient cooperation and small oral opening. This could result in increase of distance between light source and sealant. **Objective:** The purpose of the present study was to determine whether increase of distance between light source and pit and fissure sealant affected curing depth. **Material and methods:** 90 samples of pit and fissure sealant Helioclear F[®] were light-cured for 20 seconds with a Bluephase C5 LED lamp (Ivoclar Vivadent[®]), 30 seconds with the light source at a distance of 0 mm, 30 seconds at 5 mm and 30 seconds at 10 mm. Non-polymerized material was removed with a spatula for resin (Suter Dental[®]). The sample was measured in mm with an electronic Vernier caliper; obtained value was divided into two (ADA's Norm 27). Results were assessed with ANOVA and Tukey tests. **Results:** The group treated at 0 mm exhibited curing depth of 2.01 mm (SD 0.11). The group treated at 10 mm, with 1.62 mm (SD 0.08) showed the least amount of curing depth. Statistically significant differences were found in average values when comparing the three groups ($p < 0.05$). **Conclusion:** Distancing light source from sealants affects their curing depth.

Key words: Curing depth, pits and fissure sealants, LED.

Palabras clave: Profundidad de curado, selladores de fosetas y fisuras, LED.

RESUMEN

La colocación de selladores de fosetas y fisuras es un procedimiento seguro, efectivo y económico en la prevención de caries. Actualmente los clínicos prefieren lámparas de LED. Frecuentemente en odontopediatría se tienen complicaciones como falta de cooperación del paciente y tamaño reducido de la apertura bucal. Esto podría resultar en el aumento de la distancia entre la fuente de luz y el sellador. **Objetivo:** El propósito de este estudio fue determinar si aumentar la distancia entre la fuente de luz y el sellador de fosetas y fisuras afecta su profundidad de curado. **Material y métodos:** Se fotocuraron 90 muestras de sellador de fosetas y fisuras (Helioclear F[®]), durante 20 segundos con lámpara LED Bluephase C5 (Ivoclar Vivadent[®]), 30 con la fuente de luz a 0 mm de distancia, 30 a 5 mm y 30 a 10 mm. Se eliminó con una espátula para resinas (Suter Dental[®]) el material no polimerizado. La muestra se midió con un Vernier electrónico en mm y el valor obtenido se dividió entre dos (Norma 27 ADA). Los resultados fueron evaluados con las pruebas ANOVA y Tukey. **Resultados:** El grupo a 0 mm tuvo una profundidad de curado de 2.01 mm (DE 0.11) y el grupo a 10 mm fue el que menor profundidad de curado presentó con 1.62 mm (DE 0.08). Se encontraron diferencias estadísticamente significativas en los valores promedio al comparar los tres grupos ($p < 0.05$). **Conclusión:** Alejar la fuente de luz de los selladores afecta su profundidad de curado.

INTRODUCTION

Food remnants and caries-causing bacteria tend to accumulate on molars and premolars due to their morphology as well as deficient cleansing habits. For that reason, different techniques have been implemented with the aim of achieving less plaque retention in pits and fissures.¹

Dr. Buonocore, in 1955 developed the first pit and fissure sealant.² Presently, after the incorporation of acid-etch techniques, pits and fissure sealants are almost routinely used in young patients.¹

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Efficiency of sealants in caries prevention varies from 83% after one year, to 53% after 15 years.³

Sealant retention and longevity depend on three factors:

- 1) Ease of penetration of etching acid into the enamel.
- 2) Marginal sealing.
- 3) Resistance to abrasion.

This latter aspect is the most affected by decreases in the polymerization of the material.⁴

Presently, pits and fissure sealants are resin-based compounds, which include photo-initiators in their composition. Among these, we can count camphoroquinone, which is sensitive to wave lengths from 450 to 490 nm, and a strength of around 300 mW/mm².^{5,6} This wave length and strength are achieved by several light sources such as halogen light lamps, plasma arch lamps, argon laser lamps and light emitting diode lamps (LED). Presently there is a tendency to use LED lamps.

Taking into account the fact that sealants are resin-based composites, their polymerization is affected by the intensity of the light impacting upon them. When only partial polymerization is achieved, their physical and mechanical properties will be affected.

It is important to undertake the material's light curing with suitable distance between sealer surface and light source so as to allow for total polymerization of the material.

Halogen light lamps have the disadvantage of functioning through the heating of a tungsten fiber, which brings about heat generation, their designs are relatively large. Fiber optic lamps are very fragile and therefore susceptible to breakage.

LED lamps have certain advantages over halogen light lamps: they do not generate heat and their designs are light and ergonomic.⁶⁻⁸ A published study informed that the degree of conversion reached by diode-based curing units (LED) is only 5-10% lesser than the degree of conversion achieved by halogen cured units.⁷ Consequence of the aforementioned reasons is the current tendency to use LED lamps.

Presently, certain questions on LED lamp polymerization effectiveness still persist. This subject has been approached in different studies.⁹⁻¹¹ Some of these studies consider the technique used during polymerization¹²⁻¹⁵ while others have compared LED lamps with halogen lamps.^{13,15-20}

Partial polymerization can increase water absorption and unreacted monomer solubility;

this impacts on the restoration's longevity and esthetics.⁵

In pediatric dentistry, frequently one encounters the disadvantage of not having ideal circumstances for placement of pits and fissure sealants. One of these disadvantages could be the consideration that pediatric patient's mouth opening is much smaller than that of adolescent or adult patients. This in turn could result in the need to increase distance between light source and sealer, which would probably decrease polymerization depth, thus negatively impacting on mechanical and physical properties.

The aim of the present article was to determine whether distance between the light source (LED) and sealant affected curing depth of pits and fissure sealants.

MATERIAL AND METHODS

A Bluephase C5 LED lamp (Ivoclar Vivadent) was used for the present study. Sealant employed was Helioseal F (Ivoclar Vivadent).

Specification number 27 of the American Dental Association (ADA) was followed: a 20 mm x 20 mm, 2 mm thick glass was used. On it, a sample-making mold was placed (with it, 4 mm diameter and 6 mm long samples were obtained). In order to preserve distance between pits and fissure sealant surface and light source, a 5 mm long and 6 mm diameter glass tube was used. The tube was of 10 mm length and 6 mm diameter (*Figure 1*). Polymerization depth was measured in 90 pits and fissures specimens.

Specimens were assembled into three groups (30 specimens per group). One group was light-cured by placing the lamp directly upon the sealant's surface;



Figure 1. Glass base, sample making mold and glass tubes used in the present study.

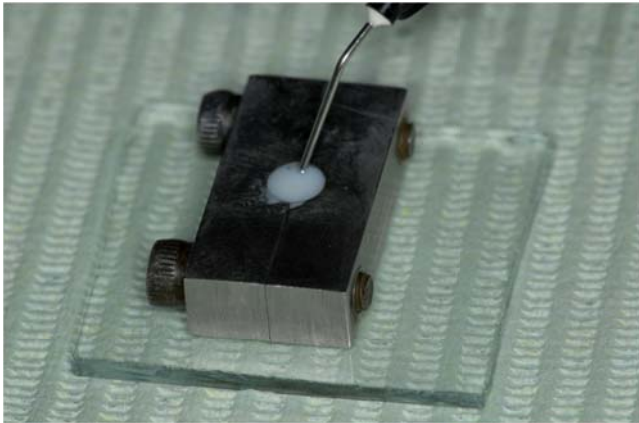


Figure 2. Placement of pits and fissures sealant in the mold on the glass base.

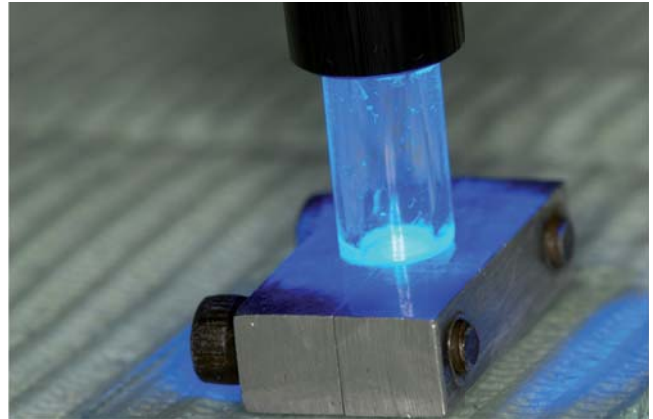


Figure 5. Light-curing at 10 mm distance.



Figure 3. Light-curing of group at 0 mm distance.



Figure 4. Light-curing at 5 mm distance.



Figure 6. Sample collection.

another group was light-cured at a controlled 5 mm distance, by placing the lamp on the 5 mm long glass tube, and the last group was light-cured at a 10 mm controlled distance by placing the lamp on the 10 mm long glass tube. All specimens were light-cured for 20 seconds, following manufacturer's instructions.

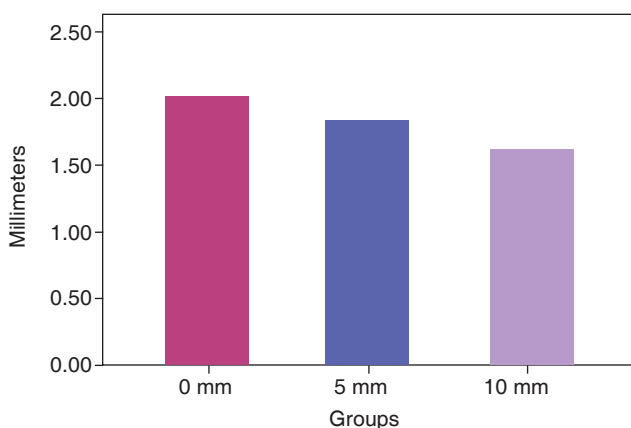
Once the light-curing process was completed, specimens were removed from the sample-maker and non-polymerized material was removed with a spatula for resin (Suter Dental®) (Figures 2 to 7).

The height of the cured material was measured in mm with a digital Vernier caliper (Maxcal, USA) and the obtained figure was divided into two (specification number 27 of the ADA). Obtained values were considered as curing depth.

Results were included in an Excel calculus sheet and processed for analysis in a Sigma Stat 2.0



Figure 7. Removal of light-uncured material.



Source: Direct.

Figure 8. Curing depth of the three experimental groups expressed in mm.

statistical package. A one way ANOVA test was used as well as a Tukey group comparison test.

RESULTS

The group light-cured at 0 mm recorded a 2.014 mm curing depth average (SD 0.113) (Table I), whereas the 10 mm group with 1.623 mm (SD 0.0847) presented the least curing depth (Figure 8). Statistically significant differences were found in average values when comparing the three groups to a $p < 0.05$ (Tukey) test (Table II).

DISCUSSION

It has been proven that resin-based compounds' polymerization with a LED lamp is 6% higher than

Table I. Average values of curing depth in the three experimental groups.

Group	Average	Standard deviation
0 mm	2.014	0.113
5 mm	1.843	0.0853
10 mm	1.623	0.0847

Table II. Tukey test results.

Comparison	$p < 0.05$
(0 mm) vs. (10 mm)	Yes
(0 mm) vs. (5 mm)	Yes
(5 mm) vs. (10 mm)	Yes

that achieved with a halogen lamp.⁸ Therefore, current trend favors use of LED lamps.

Drs Soh *et al*, found that curing depth of composite resins depended on lighting unit (lamp used) as well as on the exposition method.¹⁰

Drs Santos *et al* reported that composite resins' curing depth drastically decreased between 4 and 5 mm when using a halogen lamp, and it decreased by 2-3 mm when using a LED lamp, by placing the light source directly on the resin.²¹ These results concurred with ours, since we found significant differences in curing depth when the light source was placed directly upon the pit and fissure sealant (2.014 mm) at a 5 mm distance (1.843 mm) and 10 mm distance (1.623 mm).

Many studies have been conducted with the aim of determining the efficiency of pits and fissure sealants when considering their viscosity,^{17,22,23} their filling material,^{2,22} comparing sealants with and without pigments,^{2,17} comparing self-curing and light-curing sealants, comparing different light sources for photo-curing,^{2,6,17,24} comparing photo-curing time^{6,17,25-27} as well as comparing different preparation techniques for enamel surface (acid etch, abrasive air with acid etch, enameloplasty with acid etch).^{2,22,23} Nevertheless, studies conducted in order to determine LED lamps efficiency have not taken into consideration the distance between light source and material to be light-cured. Therefore, the present study offers a new research line.

Our results revealed that distance between light source and material to be light-cured considerably affected the light-curing quality of resin-based materials.

Depth of pits and fissures varies from 1 to 3 mm, cusps height can reach 3 mm, therefore, pits and

fissure sealants will not be able to be light-cured at a distance lesser than 3 mm.

For these aforementioned reasons, we recommend that during pits and fissures' light-curing processes, the tip of the lamp should be placed directly upon the occlusal surface of molar or premolar, so as to optimize results.

Future studies are recommended, in order to determine the conversion degree of pits and fissure sealants using LED and halogen lamps at different distances, and thus determine which of the two types of lamps is more affected by the increase in distance.

CONCLUSIONS

In the present study and following the aforementioned methodology, it was proven that curing depth of pits and fissure sealants decreases when the distance between the light source and the sealant surface increases.

We therefore can state that inadvertently distancing the sealants from the light source negatively affects their curing process, decreasing thus the quality and permanence of the material in the mouth.

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