

Influence of varying light intensity on microleakage of Class II restorations

Influência da variação da intensidade de luz na microinfiltração em restaurações Classe II

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ABSTRACT

The purpose of this *in vitro* study was to evaluate the marginal microleakage of Class II restorations photo activated with varying light intensity. Class II preparations with gingival margins were made in 80 sound human third molars. The teeth were divided into 2 groups and restored with two different resin composites (P60 and Z100). Each group was further subdivided into four subgroups, which were submitted to distinct light intensity during the polymerization process. Groups 1A and 1B received a light intensity of 550 mW/cm² in each of the three layers. Groups 2A and 2B received an exponential light intensity from 0 to 600 mW/cm² in each layer. Groups 3A and 3B received 300 mW/cm² in the first layer and 550 mW/cm² in the other two layers. Groups 4A and 4B were submitted to a light intensity of 100 mW/cm² for 10 seconds followed by 550 mW/cm² for 30 seconds in each layer. The specimens were immersed in a 2% buffered aqueous solution of methylene blue for 2 hours. The penetration of the dye was then measured under a stereomicroscope with X20 magnification. Data were submitted to the Kruskal-Wallis test and results demonstrated no statistically significant differences between the groups when differentiated by the resin composites or the light intensity, at a p-value of 0.05. In conclusion, the variation in light intensity did not significantly affect the marginal microleakage of the resin composites tested.

UNITERMS

Composite resins; dental leakage; dental restoration, permanent

INTRODUCTION

Resin composites have been largely employed in dentistry due to their aesthetics, adhesiveness, and preservation of sound tooth tissue. However, in spite of these characteristics, resin composites present a limitation since volumetric decrease occurs during the polymerization process¹⁵. This decrease occurs when the halogen light excites the charged components of the resin composite with the initiation of the polymeric conversion, leading to a decrease in the material final volume, which can cause flaws at the tooth-restoration interface^{11,23}. Marginal micro-

leakage occurs as a consequence of these flaws and is responsible for secondary caries, hypersensitivity and pulp damage. Microleakage is known to be responsible for a significant number of restoration failures. Unfortunately, the damage is often subtle and slow¹⁴.

The evolution of the resin composites enhanced their benefits allowing safer indications of aesthetic restorations for the posterior areas. Thus, these materials must present a good wear behavior, adaptation to the cavity walls and an effective sealing of the tooth-restoration interface to avoid

the penetration of oral fluids into these areas. In addition to these features, the material should be resistant to hydrolyse, easy to handle and insert, and opaque in x-rays⁶.

When aesthetics is a concern, resin composites present advantages over amalgam and cast metallic restorations for the posterior areas; moreover, the adhesive technique employed with these materials enables the saving of sound dental tissue, decreasing the size of the final restoration¹³. The adhesiveness of resin composites is an important advantage due to the conservation of the remaining tooth, allowing a less invasive restorative procedure⁵.

The polymerization process utilizing visible light is effective only in areas where the light, reaches the material with a wavelength ranging from 460 to 480nm, exciting the photo-sensible components present in the resin composites¹. However, it is uncertain the divisor line in the light intensity that, from beyond could jeopardizing the quality of the final polymerisation, and consequently the properties of the resin composites³.

The interaction of the flow and the light intensity during the polymerization process has generated confusion among researchers. Therefore, due to the difficulties of an in vivo or clinical research, and based on the reviewed literature, Class II resin composite restorations were made to evaluate marginal microleakage at the interface tooth-restoration with varying light intensity.

MATERIALS AND METHODS

The Single Bond adhesive system (3M Dental Products, St. Paul, USA) was the only material used for both resin composites: P60 (3M Dental Products, St. Paul, USA) and Z250 (3M Dental Products). The light cure units utilized during the study were Elipar Trilight (Espe Dental AG, Seefeld, Germany), Demetron 400 (Demetron Research Corp., Danbury, CT, USA), and Demetron 100 (Demetron Research Corp.).

For this study, eighty sound human third-molars freshly extracted for orthodontic reasons, and from patients ranging from 18 to 25 years old, were used. All remaining hard and soft debris were removed with the aid of periodontal hand instruments followed by cleaning with pumice and water with a Robinson brush coupled to a low speed handpie-

ce. The teeth were stored in distilled water refrigerated at 4 °C until the initiation of the restorative procedures.

To reproduce mouth positioning, a block of a chemically activated resin (Orthofalic Resin T 208, Redefibra, SP, Brazil) was made. For the positioning, two stock acrylic resin teeth were placed mesially and distally to the prepared tooth, allowing an adequate proximal contact and the use of a properly edged metallic matrix band. Soft wax was used in the roots of the prepared teeth to facilitate their removal when necessary.

Two Class II cavities were prepared in each tooth, one in the mesial and one in the distal portion, with no connection between them. A high-speed handpiece (Kavo, Joinville, SC, Brazil) was used for the preparations with continuous water spray and cylindrical diamond burs N^o 3145 (KG Sorensen, Barueri, SP, Brazil). Each diamond bur was calibrated, in accordance to a pre-established depth of 6 mm, using a water-resistant red pen. Each bur was replaced after five preparations.

Standard cavity preparations were made with an occlusal-gingival length of 6mm, a facial-lingual width of 4mm and a axial depth of 2mm. For improved standardization, a digital meter (Digimatic, Mitutoyo, SP, Brazil) was used to verify the established dimensions in the preparations.

For the restorative procedures, the teeth were divided into groups. Forty teeth (Group A) were restored with the P60 resin composite (3M Dental Products) and 40 (Group B) were restored with the Z250 resin composite (3M Dental Products). Each group was further divided into four subgroups, with 10 teeth each, and received distinct light intensities during the polymerization process.

Regardless of the group, all teeth were acid etched with 37% phosphoric acid for 15 seconds and rinsed with a water spray for 30 seconds. The excess of water was removed with sterilized cotton pellets. Two layers of the adhesive Single Bond system (3M Dental Products) were then applied to the dentine and enamel surfaces of the prepared cavity with a brush and lightly air dried for 5 seconds. The adhesive was then light cured for 15 seconds with an Elipar Trilight light cure unit, at a light intensity of 550 mW/cm².

A self-adjustable metal matrix band (TDV, Pomerode, SC, Brazil) was then placed and secured

with a wooden edge. The insertion of the resin composite was accomplished following the horizontal layering technique. Three layers (each 2-mm thick) of resin composite were necessary to fill each cavity.

For the groups A1 and B1 (with twenty prepared cavities each), each layer was light cured for 40 seconds with a Standard light intensity (± 550 mW/cm²), utilizing the Elipar Trilight light cure unit. The layers of groups A2 and B2 were light cured for 40 seconds with an exponential light intensity ranging from 0 to 600 mW/cm². For groups A3 and B3, the first layer was light cured for 40 seconds with a light intensity of 300 mW/cm² followed by curing of the remaining two layers with the Standard light intensity. A light intensity of 100 mW/cm² was utilized for groups A4 and B4 by distancing the tip of the curing unit, light intensity was verified with a radiometer. For improved standardization of the distance, a hard and transparent plastic tube, 22 mm in length, was coupled to the tip of the light cure unit.

Following finishing and polishing of the restorations, the specimens were stored at room temperature in distilled water for one week. After the storage time all specimens were painted with two coats of nail polish intercalated with white wax (Artigos Odontológicos Clássico Ltda., São Paulo, SP, Brazil). The tooth-restoration interface was not coated at the gingival margin and 2mm around the margins of the preparations to allow the penetration of the methylene blue dye.

After the completion of the restorative procedures, the specimens were stored in a buffered 2% aqueous solution of methylene blue for 2 hours. The specimens were then removed from the dye solution, rinsed in running tap water for 20 minutes, and allowed to air dry for 24 hours prior to the

removal of the painted coats. The specimens were then mounted in an acrylic resin base plate and sectioned mesio-distally. For the sectioning procedure a diamond wheel saw (South Bay Technology Inc, model 650, San Clemente, CA, USA) was utilized.

After the sectioning, the sample that presented the highest dye penetration, from each restoration, was selected before being scored. A qualitative analysis was made and the extension of methylene blue penetration was measured under a stereomicroscope (Micronal VMT – São Paulo, SP, Brazil), with X20 magnification. Two independent evaluators, familiar with this *in vitro* technique, evaluated all specimens, and the highest microleakage score for each site was used for the statistical analysis. The specimens were scored as described in Table 1.

RESULTS

None of the procedures tested in this study completely eliminated microleakage. The scores are presented in Tables 2 and 3.

The results for the Kruskal-Wallis test ($p \leq 0.05$) showed that there was no statistically significant difference between the resin composites, P60 ($p = 0.2984$) and Z250 ($p = 0.2196$) when differentiated by the light intensity employed. Groups 1A and 1B ($p = 0.7119$), which were subjected to the Standard light intensity, were not significantly different from each other. Similar results were obtained for groups 2A and 2B ($p = 0.7651$), which utilized medium light intensity (300 mW/cm²) and Standard light intensity; and groups 4A and 4B ($p = 0.4236$), which utilized low light intensity (100mW/cm²) and Standard light intensity in each layer. These results are depicted in Table 4.

Table 1 - Microleakage scores

Microleakage score	Penetration
0	No dye penetration
1	Partial dye penetration along the gingival wall
2	Dye penetration along the gingival wall, but not including the axial wall
3	Dye penetration along the axial wall

The data were submitted to the Kruskal-Wallis non-parametric test, with the p-value set at 0.05.

Table 2 - Microleakage scores obtained for each experimental group using P60 resin composite

	Score 0	Score 1	Score 2	Score 3
Group A1	5	8	-	7
Group A2	6	9	2	2
Group A3	4	8	1	5
Group A4	8	7	4	1

Table 3 - Microleakage scores obtained for each experimental group using Z250 resin composite

	Score 0	Score 1	Score 2	Score 3
Group B1	4	7	3	6
Group B2	7	9	-	4
Group B3	7	8	3	2
Group B4	7	5	5	3

Table 4 - Results for the Kruskal-Wallis test ($p \leq 0.05$)

	H	(p) Kruskal-Wallis	
Z250	4.4198	0.2196	a
P60	3.6779	0.2984	a
LI 1 (550mW/cm ²)	0.1364	0.7119	a
LI 2 (0 to 600mW/cm ²)	0.0893	0.7651	a
LI 3 (300mW/cm ² and 550mW/cm ²)	2.1003	0.1473	a
LI 4 (100mW/cm ² + 550mW/cm ²)	0.6404	0.4236	a

LI = Ligth Intensity

Averages followed by the same letter in the column do not differ one from the other at a 5% level of significance

DISCUSSION

Marginal microleakage is one of the main drawbacks presented by resin composite restorations. This deficiency occurs due to many factors, including the polymerization shrinkage that causes tension at the tooth-restoration interface, leading to flaws and decreasing the longevity of the restorations. The microleakage test is the *in vitro* method most employed to evaluate the marginal sealing of restorations, and the method possesses well-defined criteria in the literature.

In this study, a 2% buffered solution of methylene blue dye was employed as the immersion medium for the specimens for two hours⁴. In accordance with the methodology suggested by Déjou et al.⁹(1996), the sample with the highest dye penetration for each site was the one utilized for evaluation and scoring for statistical analysis.

The results showed that the majority of the samples tested presented dye penetration, regardless of the light intensity employed during the polymerization process, suggesting the formation of gaps at the

tooth-restoration interface which allowed this microleakage. It may be speculated that, as a clinical consequence, this microleakage could cause secondary caries, tooth sensitivity, and pulp damage. These findings are in accordance to those reported by Mehl et al.¹⁶(1997), and Friedl et al.¹⁰(2000), who employed similar light intensities to the ones utilized in this study. However, the findings of this study disagree with those of Yoshikawa et al.²⁴(2001), who tested a soft-start polymerization light with an output of 270 mW/cm² for 10 seconds, considered a medium light intensity, followed by an output of 600 mW/cm² for 50 seconds, which led to statistically superior results when compared to conventional and low light intensities.

Polymerization shrinkage is a complex process, resulting from the interaction of several factors, and generating tensions that are compensated, at first, by the material flow⁷. The velocity of polymerization appeared to be an important factor contributing to the distribution of the internal stress¹². Goracci et al.¹¹(1996) suggested that an alternative to reduce the polymerization shrinkage and its consequences is the prevention of the rapid increase in the viscosity of a material caused by the intense light emission found in conventional light cure units.

High intensity light cure units are broadly recommended generally based on an increased polymerization depth, enhancing the material physical properties². However, the possibility of the induction of tension and the avoidance of its relaxation must be considered¹⁶. High intensity light emission over a resin composite leads to a rapid polymerization of the material; therefore, a less viscous state (pre-gel) is rapidly transformed into a stiffer state (post-gel), with a considerable increase in the modulus of elasticity²¹. Up to the gel phase, when the polymeric chain is already formed obstructing the flow of the material, a molecular rearrangement is still able to release the generated tensions. After the development of the material rigidity, the great decrease of its flow enhances the concentration of tensions⁷. Therefore, a high light intensity leads to a low and limited tension relief, due to a decreased pre-gel phase, where the polymerization tensions could be compensated²⁰.

In this study, groups 2, 3, and 4 demonstrated the influence of the light intensity upon marginal microleakage of resin composites restorations; however, no statistically significant difference was

found between the control group (Standard light intensity), and the other groups. In the group 2, which utilized exponential light, the intensity of 250 mW/cm² was reached in approximately 10 seconds, decreasing the flow time and the release of the tensions. This behavior is close to a conventional polymerization process. Similarly, in group 3, the light intensity utilized in the first layer was 300 mW/cm², considered to be a medium intensity, followed by an output of 550 mW/cm², resulting in a light energy density of 56 J/cm² when summing the three layers. In contrast the conventional polymerization resulted in 66 J/cm². For the calculation of the light energy density the formula, X intensity time¹⁹ was employed, not considering therefore, the flow or significant differences in microleakage. The results in group 4, where the soft-start polymerization was employed with an initial output of 100 mW/cm², followed by a complementary light intensity of 550 mW/cm² in each layer, showed no statistically significant differences in microleakage from the other groups.

Considering that a low light intensity of 100 mW/cm² is not enough for complete polymerization due to the inability to properly activate the photo-initiators present in resin composites¹⁶, and that 10 seconds is a quarter of the total exposition time, resin composites exposed to a conventional light intensity behave similarly to non pre-polymerized ones, with no relief of the generated tensions, as showed by Friedl et al.¹⁰(2000). Sakaguchi & Berge¹⁹ also showed that there were no significant differences in the polymerization shrinkage and in the polymeric conversion when comparing two distinct light intensities, one low and one high, to a more conventional one.

The tension generated during the polymerization shrinkage of a resin composite antagonizes the adhesiveness at the dentine surfaces during the polymerization process. The C-factor⁸, is the ratio between the adhered surfaces and the free surfaces, the higher the C-factor the higher the probability of an adhesive failure at the dentine-resin interface composite restoration during the polymerization shrinkage in the entire cavity, especially during a bulk insertion¹⁷, these findings are in agreement with the results of this study due to the high level of penetration of the methylene blue dye.

Suliman et al.²² showed that the size of a restoration, the C-factor, the insertion technique (layering or

bulk), the activation method (chemical or photo-curing) and the material composition, influence the development of stresses during the pre-gel phase, the authors further suggested that the proximal cavity configuration, a box type, might have had an effect upon the outcomes of the study. Moreover, Nordbo et al.¹⁸(1998), showed that a round, or saucer, cavity configuration presents advantages over a box type due to the direction of the force vectors during the polymerization shrinkage. The box configuration develops high levels of tensions at the interfaces, while in the round configuration the vectors are directed toward the free surfaces, favoring the flow of the material. The choice of the cavity design used in this study was made due to the high incidence of amalgam restoration substitution that possesses this configuration.

Sakaguchi et al.²⁰(1992), stated that the occlusal-cervical extension of cavities presents clinical difficulties during the insertion of resin composites, what could lead to a poor adaptation of the material, causing gaps and consequently increasing microleakage. Moreover, the distancing of the emission light device from the cervical margins, decreases substantially and critically the light intensity at these areas and could influence the appearance of flaws at the tooth-restoration interface.

In this study, no statistically significant difference was demonstrated between the resin composites, Z250 (indicated for universal use) and P60 (indicated for posterior restorations). It may be speculated

that the similarity in the resin composite formulations was responsible for the outcomes. The inorganic filler content of both materials is composed of Zirconium/Silica particles; Z250 with 60 vol. %, and P60 with 61 vol. % of inorganic fillers, without the silane agent and with a particle average of between 0.19 and 3.3 μ m. Moreover, the organic matrixes of P60 and Z250 possess Bis-GMA, UDMA, and Bis-EMA. Thus, further research with the utilization of materials possessing distinct compositions, which could give different outcomes, is recommended.

The literature presents studies with different results, employing similar methodologies or with small discrepancies, making more detailed studies necessary or clinical studies that could provide information about the longevity of restorations polymerized with distinct light intensities.

CONCLUSION

The variations in the light intensity did not show statistically significant differences in microleakage when evaluating the sealing capability of the two resin composites tested, or statistically significant differences in the averaged medium values of these materials.

Under these test conditions, most of the restorations could not prevent microleakage of the utilized dye solution.

RESUMO

A proposta deste estudo foi avaliar, in vitro, a infiltração marginal em restaurações classe II de compósitos fotoativados com diferentes intensidades luminosas. Foram utilizados 80 dentes terceiros molares, com preparos cavitários ocluso-proximais com término cervical em dentina. Estes dentes foram divididos em dois grupos os quais foram restaurados com os compósitos Z250 e P60 (3M). Cada grupo foi dividido em quatro subgrupos os quais receberam intensidade luminosa diferenciada durante o procedimento restaurador. Nos subgrupos 1A e 1B foi empregada a intensidade de ± 550 mW/cm² nos três incrementos; nos subgrupos 2A e 2B a intensidade foi exponencial de 0 a 600 mW/cm² em cada incremento; nos subgrupos 3A e 3B, no primeiro incremento a intensidade foi de 300 mW/cm² e 550 mW/cm² nos outros dois incrementos, e nos subgrupos 4A e 4B a intensidade foi de 100 mW/cm² por 10 segundos, seguido de 550 mW/cm² por 30 segundos para cada incremento. Para fotopolimerização foi usado o aparelho Elipar Trilight (Espe). Em seguida, as amostras foram cobertas com duas camadas de esmalte para unha e cera rosa para então serem imersas em solução corante de azul de metileno a 2% tamponado por duas horas. Após o seccionamento as amostras foram analisadas em lupa esterioscópica Zeiss com 20X de aumento onde foi mensurada a extensão da penetração do corante e transformada em escores. Os dados foram submetidos à análise estatística empregando-se teste Kruskal-Wallis. Concluiu-se que não houve diferença estatisticamente significativa ($p > 0,05$) entre os materiais restauradores utilizados bem como para a intensidade luminosa.

UNITERMOS

Resina composta; infiltração dental; restauração dentária permanente

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