Effects of composite resin curing by the pulse-delay cure

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ABSTRACT

The type of curing is the factor that influences the stress generated during curing shrinkage. The light energy applied on the composite resin bulk filling should produce a surface with high wear resistance, low shrinkage and better marginal sealing. Suh (1999) advocated the pulse-delay cure with a view sealing the cavosurface margins of restorations. Class I cavities measuring 4mm in length, 2 mm in width and 2 mm in depth were prepared in 45 bovine central incisors, transversely to the long axis of the tooth. This cavity was selected because it presents a factor C = 4. Three curing techniques, namely single increment, gradual and pulse-delay cure, were employed on the restorations accomplished with the Suprafill (SS White) hybrid composite, the matrix of which is mainly composed of BISGMA. The adhesive system employed was that indicated for this composite resin. The results revealed that the pulse-delay cure is an adequate method and may be indicated to reduce or even eliminate gaps, providing better marginal sealing. The Suprafill resin did better when cured by the gradual technique or the pulse-delay cure, since curing by light activation occurs very rapidly, from 40 to 60 seconds, and does not allow the composite resin to flow, which then hardens immediately.

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KEY WORDS: composite resin, pulse-delay cure, curing

INTRODUCTION

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Polimerization shrinkage is a top problem in composite resins, which is associated to the formation of marginal fissures. These fissures produce in the composite resin restorations marginal infiltrations, marginal stainings, post-operative sensibility and the of secondary caries.

The method of activation is a factor that influences the properties and is able, when adequately used, to decrease the shrinkage and minimize the marginal infiltrations. The polimerization is related to the incidence of energy (Light emission energy = light intensity x exposure time $\xi = I.\ T$) and to the light source; such characteristics enable the resin to show a variable flow of its mass during polimerization (NAGEM FILHO, 2000).

Koran and Kürschner (1998) studied the effect of the sequential application of light intensity during polimerization of resin, starting with a period of low light intensity complemented later by high intensity. They concluded that one sequential application of polimerization leads to the same shrinkage in relation to only one dose of irradiation. However, the marginal sealing can be improved.

Pereira (1999) evaluated the effects of the technique of insertion for the ability of sealing of class II restorations. Results showed a greater index of infiltration with the technique of unique increment. The techniques of various increments show better results but Lutz, Krejci and Oldenburg (1986) disagree. In their study they did not find differences in the use of the developmental technique as compared to that of one block in the infiltration in restorations with composite resin.

The energy of light applied in the resin mass should produce a surface of high resistance to wearing, low shrinkage and better marginal sealing (NAGEM FILHO, 2000). The pulse technique aiming to seal the cavosurface margins of restorations was recommended by Suh (1999). The variety of intensity (I), the time of exposure to light (t), the amount of mass to be polymerized (depth) and the resin being introduced in a block or stratified have controversies caused on the efficiency of this method and to arise doubts among researchers (PEREIRA 1999; SOUZA Jr., CARVALHO; MONDELLI 2000). For this reason the aim of the present study is to evaluate the techniques of polimerization regarding the efficacy of suppressing marginal infiltration.

MATERIALS AND METHODS

To the test of marginal microleakage were used 45 central incisive bovine teeth (average size 0.4 cm wide and 5 cm long). Teeth were cleaned with pome stone suspension and in the vestibular surface of each tooth it was made a cavity 4 mm long, 2 mm wide and 2 mm deep in transversal position to the loner axis of the tooth. These measures were controlled and checked with a pachymeter in order to obtain cavities as similar among themselves as possible. The cavosurface margins were prepared at 90º and no bevel was done. This type of cavity was selected due to the fact that it shows a C factor = 4 (this factor is the relation between the adhered and non-adhered surfaces). The conditioning with 37% phosphoric acid was made for 15s with a brush along the cavity. Then, it was rinsed with water and dried with air stream, maintaining the superficial moisture recommended by the manufacturer of the adhesive system.

The composite resin (Suprafill) was introduced with a nº 2 Thompson spatula up to the level of the cavosurface margin of the preparation, 2 mm wide.

FIGURE 1 – Tooth inclusion.

In the present study were used 45 bovine superior central incisive teeth. To achieve three equitative groups with causal constitution it was made a raffle by means of the causal process using a table of random number, with 15 teeth restored to each polimerization method (integral, gradual and pulse).

In group I the polimerization took 40 seconds and with 600 mw/cm^2 high intensity. In group II, three increments, disposed one in each proximal and other in the center, were successively exposed to light of 600 mw/cm[2] with a pre-determined time of 40 seconds for each segment (gradual technique). The pulse technique was used in group III (KANCA III, 1999; SUH et al., 1999). The initial polimerization was 3 seconds at 200 mw/cm[2] (low intensity). After a rest period of 3 to 5 minutes the finishing and polishing was done, while the stress relaxing was occurring. After the defined period the final polimerization took place for 30 seconds to 600 mw/cm[2], being10 seconds to the mesial proximal facet, 10 seconds to the distal and 10 seconds in the center of the restoration (high intensity).

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All procedures were done with the photopolimerizer VIP from *Bisco Dental Products Inc* and were performed by a sole operator aiming to eliminate variability. In this sense, for the same cavity model three different techniques of polimerization totaling 30 class V restorations that were analyzed for microleakage.

After polimerization teeth were stored for 24h in distilled water and two groups were submitted to the standard finishing process using diamond golden points to remove excess. For polishing the resin surface flexible abrasive discs of alluminium trioxide (Solf-Lex – 3M) were used in decreasing order of abrasivity. They were used with light pressure and in circular movement with intermitend water jets. The third group, submitted to the pulse technique (KANCA III, 1999; SUH et al., 1999) was finished and polished following the same procedure, 3 to 5 minutes after the first application of light energy in the surface.

TABELA 1 – The various polimerization techniques

1st Condition	2nd Condition	3rd Condition
Block polimerization (Integral polimerization)	Gradual polimerization	Pulse polimerization (Pulse-Delay)
I = 600 mw/cm2 (high intensity) T = 40 seconds	I = gradual of 600mw/cm2. T = 40 secons each increment	I initial = 200mw/cm2 (low intensity) T initial = 3 seconds I final = 600mw/cm2 (high intensity) T final = 30 seconds

Legends: I = Intensity of light. / T = Time of exposition.

Tooth preparation included washing in distilled water and drying in absorbing paper. The roots were removed with a carbodurum disk at the amelodentinal junction. After finishing and polishing teeth were thermocycled for 100 cycles in temperatures between 5ºC and 55ºC with 1 minute immersion period of. Then, they were included in epoxy resin till the region of the neck supported by pieces of 3 cm long PVC tubes 3/4. To avoid the penetration of the revealing substance it was applied to the tooth surface 3 layers of cosmetic enamel (Colorama) for impermeabilization, respecting the limit of 1 mm off the cavity contour.

Each tooth, adequately labeled, was immersed in a 0.5%, pH 7.2 methylene blue aqueous solution and stored in a stove at 37ºC ± 1ºC, 100% of relative humidity for a period of 72h and then rinsed for 2h and dried.

After the experimental period, teeth were rinsed in flowing water and dried. The impermeabilization was removed with a thin scapel blade. Then, teeth were cut in the middle of the restoration with a precision metalographic scizor (IOM, model PC10) using diamond discs, from the incisal region to the cervical region, resulting in two longitudinal halves.

FIGURE 2 – Longitudinal cut.

The blocks sandpaper in decreasing granulation until 1200 and submitted to exam in a stereoscope with 64 x magnification and infiltration rates were recorded according to the criteria of evaluation and classification of the amount of infiltration of the stain in the restorations regarding the marginal integrity, in both surfaces, mesial and distal (PEREIRA, 1999). The method used was qualitative by means of pre-fixed rates.

TABLE 2 - Values for classification in what regarding the marginal integrity and the criteria for coronal inflitration grades.

Grade of inflitration	Depth of penetration
0	No penetration detected. There is no visible evidence of infiltration along the margins. The stain is found not far from the amelodentinary junction.
1	Less than 1mm. There is visible or perceptible evidence of infiltration that extend to the dentin, beyond the amelodentinary junction.
2	1 to 1.5mm. There is deep infiltration and the stain can be seen in the proximities of the pulp region.

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The infiltration values were submitted to non-parametric statistical analyses by the *Krukal-Wallis* test, at a 5% level of significance aiming to identify the possible differences of penetration of the stain among the different types of resin polimerization.

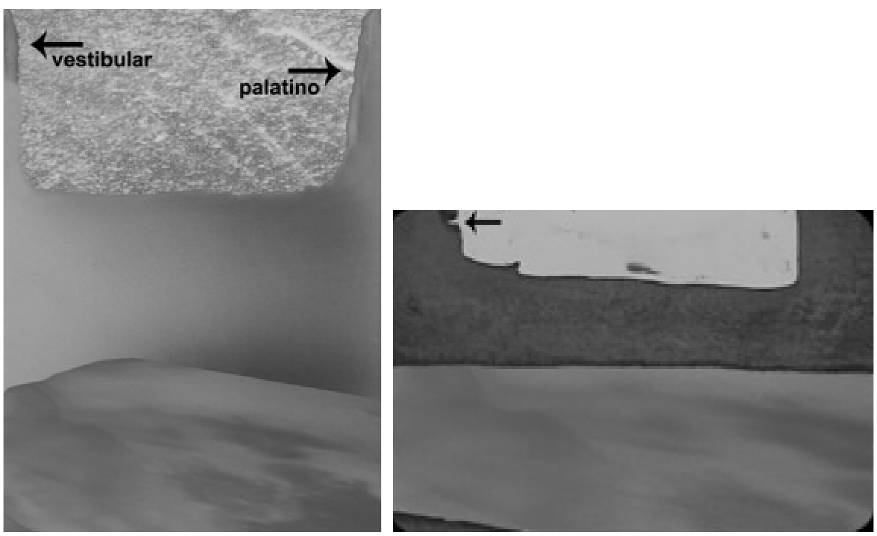

FIGURE 3 – Marginal infiltration.

RESULTS

The resins showed significant difference regarding the exposition to radiation in different manners. The results are contradictory and the properties are modified according to the polimerization method.

TABLE 3 – Median, mean, standard deviation, sum, minimal and maximal values.

Polimerization	Median	Man	s. d.	Sum	Mín.	Máx .	N
Block	2.0 A	1.6	0.5	16.0	1.0	2.0	10
Gradual	1.0 B	1.1	0.8	11.0	0.0	2.0	10
Pulse	0.0 C	0.2	0.4	2.0	0.0	1.0	10

Note: different letters mean differences among polimerizations.

Although in term of means the block and gradual technique did not show significant results they cannot be accepted because the non-parametric values of the data obtained on infiltration did not represent the truth. The statistical method was made by the mean and the semi-amplitude of the values of penetration of the staining substance according to the tested material and the polimerization technique used.

DISCUSSION

The top cause for failure in restorations until now has been the microleakage in the cavity margins leading to percolation, alteration of color in the margins, caries recurrence, pulp inflammation, affecting the integrity and the longevity of the restoration (PASHLEY, 1990; FERDIANAKIS, 1998). The failure in the marginal sealing can be due to many factors such as the polimerization shrinkage, the difference between the rate of thermal expansion of the material and that of the tooth structure and the weak or absent chemical bond between the dentinary substract and the restorative material (FERDIANAKIS, 1998).

The degree of composite resin shrinkage depends on various factors. However, for Versluis and Tantbirojn (1999), the minimal group of properties to analyze the shrinkage stress is given by the volumetric or linear contraction, if this is isotropic, and by the module of elasticity, for a given configuration of the cavity. As the C factor and the resin mass volume in the present study were equal and constant, the variation of the stress is only dependent of the speed of reaction induced by the energy used, that is, by the exposition of the light intensity and the time of photopolimerization. The values showed that a slow initial speed (3s) followed by an exposition to a greater period (30s) revealed better results concerning the marginal leakage than that of the higher speeds.

Watts and Al Hindi (1999) evaluated the hypothesis of a composite resin was able to show differences in relation to the kynetics of polimerization contraction in what regards the different techniques of photopolimerization. The application of light intensity in only one intensity showed differences in relation to the gradual technique. The resin that received an irradiation of low intensity followed by a dose of high intensity showed less shrinkage. Christensen et al. (1999) report that the shrinkage stress can be minimized by extending the pre-gel phase. In this way the gradual polimerization, by reducing the light intensity, followed by photoativation with high intensity in the final layer improve the marginal integrity of restoration and has been proved by many studies (KORAN; KÜRSCHNER, 1998; FENG; SUH, 1999; LOSCHE 1999; WANG; SUH, 1999). The gradual polimerization by pulse activation showed better results as compared with conventional techniques. It showed less shrinkage stress and better marginal adaptation pointing out that the time interval between the two phases of polimerization is critical in this technique once the resin continue to be polymerized despite the absence of light (YAP; WONG; SIOW, 2003).

On the one hand, it is acceptable, for example, that a low application of light intensity in the beginning of the polimerization, probably, is associated to the relation of formation of few centers of polimer growth that should result in a longer linear chain with few cross-links. In the other hand, when a high energy of irradiation is applied, such as 60s of light exposure for a width of 0.5 mm of brown resin as recommended by Onose et al. (1985), it is possible the formation, in the initial phase, of multiple growth centers leading to a polimer with a greater number of cross-links become possible; even with a high tax of conversion, the composite resin based in a polimer with a low number of cross-links can be sensitive to the action of the flow, depending, in this case, on the type and on the percentage of charges it has (RAADAL, 1979). In this context, Suprafill has a linear or scarcely branched BISGMA. As the last layer of the resin applied in the restoration receives a low energy by the pulse technique, the flow or accommodation of the mass, in the

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beginning of the polimerization, it will be greater, proceeding with the expansion and the closure of the fissures. In the final phase, the superficial exposed surface of the resin, as it receive an high irradiation energy, will provoke the complete hardening of the resin mass and the marginal sealing with an adequate resistance to bear the chewing forces or the brushing process. As the resin undergo only one exposition of light with high irradiation, it shows other characteristic in its properties. Most shrinkage stress occur within the 15 minutes after the beginning of polimerization, but the activated light for polimerization has a rapid period, circa 40 to 60 seconds, not permitting the flow of resin and leading to a quick hardening (RETIEF, 1994). As a result, in the beginning of the polimerization occurred the activation of most of the canphoroquinone molecules and, in this way, the increase in the number of the growth centers rose. As a result, the propagation of the polimerization might form short chains of branched polymers and the hardening will be fast impairing the sealing of fissures and the marginal sealing. The microleakage reduction is attained by using the incremental technique, and becomes more resistant when the restoration is exposed to chewing stress or occlusal loads (RETIEF, 1994). However, results are more satisfactory and adequate when this technique is complemented by the application to the pulse technique, in the superficial layer. Suprafill resin showed better results in the two conditions when the polimerization was gradual or in pulse, revealing that its molecular structure seems to influence the results. This can be a characteristic of this resin to suggest the use of pulse technique. However, it should be stressed that with other resins this technique is adequate and can be used.

Although the results showed statistical significance among the techniques with block, gradual or pulse, it is not possible to predict the supremacy of one of them concerning the clinical longevity of the restoration. Further studies are needed to determine the effects of the irradiation of the polimerization light in composite resins with different molecular weight (mass). Furthermore, the present findings, as well al those of the future, should be evaluated keeping in mind its influence in the microleakage *in vivo*.

CONCLUSIONS

Polimerization by pulse technique is an adequate method and can be indicated for reduction or even elimination of fissures leading to a better marginal sealing;

Suprafill resin showed better results in the two conditions in which the polimerization was gradual or by pulse;

The polimerization by photoactivation has a short period, circa 40 to 60 seconds, and does not allow resin flow, promoting immediate hardening.

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