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Evaluation of the Cervical Integrity During Occlusal Loading of Class II Restorations

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Clinical Relevance

The periodical supervision of packable composite proximal restorations is necessary and essential, as microleakage greatly increases after axial mechanical load incidences, even when this material is associated with other materials, such as flowable composite, glass-ionomer or compomer.

SUMMARY

There are many concerns regarding the clinical behavior of packable composite restorations in Class II cavities, particularly when those restorations are subjected to axial mechanical loads. This study evaluated microleakage *in vitro* in proximal vertical "slot"-type cavities with walls located in enamel and dentin, filled with packable composite, associated or not associated with a flowable composite, a reinforced light-curing glass-ionomer or a compomer, after being submitted to occlusal load cycling. These preparations were subjected to either occlusal load cycling or no occlusal load cycling.

Eighty human molars with enamel and dentin margins were treated with standardized cavity preparations (proximal vertical "slot" preparations). After completing the filling process using a packable composite (Filtek P60) with or without a cervical increment of flowable composite (Filtek flow), light-curing glass-ionomer (Vitremer) or compomer (Dyract AP), the molars were separated into two groups: control (without occlusal loading) and test, in which 4,000 one-second cycles of 150 N occlusal loading were applied. All 80 teeth were submitted to a microleakage test, then evaluated utilizing silver nitrate dye penetration. Significant statistical differences (Wilcoxon test, *p*<0.05) in the amount of leakage in enamel and dentin were found in both the control and test groups. After a paired comparison of

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the control and test groups, a significant statistical difference was found at the enamel level (Mann-Whitney test, *p*<0.05). In dentin, the only statistically significant difference found was the relation to the flow material. The Kruskal-Wallis test did not detect any statistically significant difference in the amount of leakage among the four materials studied, with a 5% level of significance for both enamel and dentin. Based on this data, it was concluded that restorations with margins located in dentin had greater microleakage than those restorations with margins located in enamel. When the samples were submitted to occlusal loading, they were negatively influenced, which increased microleakage values in enamel and dentin. There was no statistically significant difference among the four tested materials, when comparing their performance.

INTRODUCTION

Although many researchers[1-2] have shown the significant improvement of composite filling and have demonstrated that aesthetic posterior fillings may have relative clinical success, other studies[3-4] emphasize the clinical limitation of this material, mainly regarding microleakage, which causes post-operative sensitivity and recurrent caries.

In the 1990s, a new class of composites, known as condensable composites, was released to the market, offering the possible conjunction of conventional composite esthetics with an amalgam condensation property. Some studies[5-6] have shown that these packable composites have good mechanical properties. Loguercio and others[6] asserted that packable composites have less polymerization shrinkage than hybrid composites, which resulted in lower microleakage values in the cervical walls of Class II restorations.

When considering the behavior of this material in Class II cavities, no one has shown that current restorative systems can hermetically seal a cavity until now, particularly when restorative systems are submitted to axial mechanical loads. When a new material is presented, many doubts are created in terms of the clinical success of that material. Some doubts are related to the clinical performance of the material after occlusal load cycling and how the load cycling would affect microleakage in that material. Campos, Sampaio Filho and Barceleiro[7] have shown that packable composite fillings with cervical margins in cementum/dentin had greater microleakage in dentin when compared to enamel. When samples were submitted to occlusal loading, the rate of marginal microleakage increased, both in enamel and cementum/dentin.

As some authors[8-9] have reduced the degree of microleakage in the cervical walls by including an initial increment of either a flowable composite or a reinforced light-curing glass-ionomer prior to using the packable composite, this study evaluated microleakage *in vitro* in proximal vertical "slot"-type cavities filled with packable composite, which were associated or not associated with a flowable composite, a reinforced light-curing glass-ionomer or a compomer, before and after being submitted to occlusal load cycling.

METHODS AND MATERIALS

Eighty recently extracted human maxillary third molars, with no evidence of enamel cracks, were stored in 0.5% thymol solution until beginning the experiment. All the teeth were prepared with two standardized Class II proximal vertical slot cavities, one in the mesial face and the other in the distal face. They were prepared with #2143 (KG Sorensen, São Paulo, Brazil) diamond points in a high speed turbine (Kavo, Santa Catarina, Brazil) with oil-free water irrigation. The diamond points were changed after every three preparations. All the cavities had 3 mm between the vestibular and lingual walls and were 2 mm deep from the axial wall. The cervical wall limit was established 1 mm above the enamel-cementum junction (wall in enamel) for one cavity per tooth and 1 mm below the enamel-cementum junction (wall in dentin) in the other cavity per tooth. None of the cavosurface angles of the preparations had beveled edges.

The teeth were divided into two groups, control (without occlusal loading) and test (with occlusal loading), and each group was divided into four subgroups according to the material used; Filtek P60, Filtek P60 + Filtek flow, Filtek P60 + Vitremer or Filtek P60 + Dyract AP. Table 1 features the materials used and their manufacturers.

After cavity preparation, the teeth were cleaned for 30 seconds with a fine powder of pumice, using a rubber cup and a low-speed handpiece. An individual metallic matrix fixed by a matrix retainer was used to create the lost proximal wall. The teeth were then restored as follows:

- **Filtek P60 subgroup:** Cavities were conditioned with 37% phosphoric acid (3M ESPE, St Paul, MN, USA) for 30 seconds in enamel and 15 seconds in dentin. The surfaces were rinsed with dis-

Table 1: *Materials Used in the Restorations*

Material	Manufacturer	Lot #
Adper Single Bond 2	3M ESPE	2HC
Filtek P60	3M ESPE	3TN
Filtek flow	3M ESPE	1CL
Dyract AP	Dentsply	9703000228
Vitremer	3M ESPE	3BE–Powder/2BN-Liquid

tilled water for 30 seconds, then gently dried with oil- and dust-free air for two seconds. Next, the Adper Single Bond 2 (3M ESPE) adhesive system was applied according to the manufacturer's instructions. A thin layer of the product was applied with a brush and left undisturbed for 30 seconds. The solvent was removed with oil- and dust-free air jets for two seconds. An additional layer of the adhesive was applied and immediately dried, similar to the first layer, and the surface was light-cured for 10 seconds with an Optilux 401 (Demetron, Kerr Corporation, CA, USA) light source (intensity = 400 mW/cm^2, evaluated with a radiometer after every 10 uses). The cavities were then restored with three portions of Filtek P60 packable resin, according to the restorative technique presented by Lutz and others[10] (one cervical portion, one vestibular portion and one lingual portion), with each portion light-cured for 60 seconds. After restoration, the samples were stored for seven days in distilled water at 37°C.

- **Filtek P60 + Filtek flow subgroup:** The cavities were restored as described previously, except that the Filtek flow flowable composite was used for the first increment (cervical) and light-cured for 60 seconds. Filtek P60 was used for the other two increments.
- **Filtek P60 + Vitremer:** The cervical walls were first restored with Vitremer, according to the manufacturer's instructions. The cavities were treated for 30 seconds with the Primer solution that came in the product kit. Oil- and dust-free air jets were applied for two seconds, and the surface was light-cured for 20 seconds with an Optilux 401 source. The powder and liquid were then mixed at a 1:1 proportion for 45 seconds, with the mixed material applied to the cavity with Centrix points. This initial increment was light-cured for 10 seconds with an Optilux 401 source. This increment was substituted for the first cervical increment used in the first subgroup. Then, the remaining increments were applied as described in the first subgroup, beginning with acid conditioning.
- **Filtek P60 + Dyract AP:** The cavities were restored as described in the first subgroup, except that Dyract AP compomer was used for the first increment (cervical) and light-cured for 60 seconds. Filtek P60 was used for the other two increments.

After the cavities were filled, the test group was prepared for mechanical loading as follows: the roots were coated with melted wax up to 2 mm below the enamel-cementum junction. A PVC cylindrical tube (Tigre, São Paulo, Brazil), 21 mm in diameter and 25 mm high, was used to attach the teeth in auto-polymerizing acrylic resin (Classico, São Paulo, Brazil) up to the wax level mark (two millimeters below the cemento-enamel junction). A deliner (Bioart, São Paulo, Brazil) was used to ensure that the teeth were attached with the cusps parallel to the base. Thus, the load coming from the test equipment (EMIC MF dl 500) was equally distributed among the cusps according to Davidson and Abdalla[11] and Raadal.[12] The teeth were then removed from the acrylic resin and wax was substituted with additional silicone (Imprint II, 3M ESPE). The excess silicone was removed with a Le Cron spatula at the level of the area previously marked as the fulcrum (2 mm below the cemento-enamel junction). After preparation, the teeth underwent 4000 loads at 150 N, each load lasting one second, using a universal testing machine controlled with a software program (TESC version 1.08).

All the teeth were immersed in a 50% silver nitrate dying solution for four hours (Taylor & Lynch[13]). Upon completion, the teeth were longitudinally sectioned with a mesio-distal cut, using a slow-speed diamond saw (KG Sorensen) under irrigation. As a follow-up procedure, two pre-calibrated professionals evaluated the tooth halves according to the amount of dye microleakage by means of a 40x magnifying glass. The microleakage was scored using the following scale: 0 = no leakage; 1 = leakage up to the dentin enamel junction; 2 = leakage beyond the dentin enamel junction without reaching the axial wall; 3 = leakage reaching the axial wall.

RESULTS

Figures 1 to 4 show the percentage results from the different subgroups.

Significant statistical differences (Wilcoxon test, $p<0.05$) in the degree of leakage in enamel and dentin

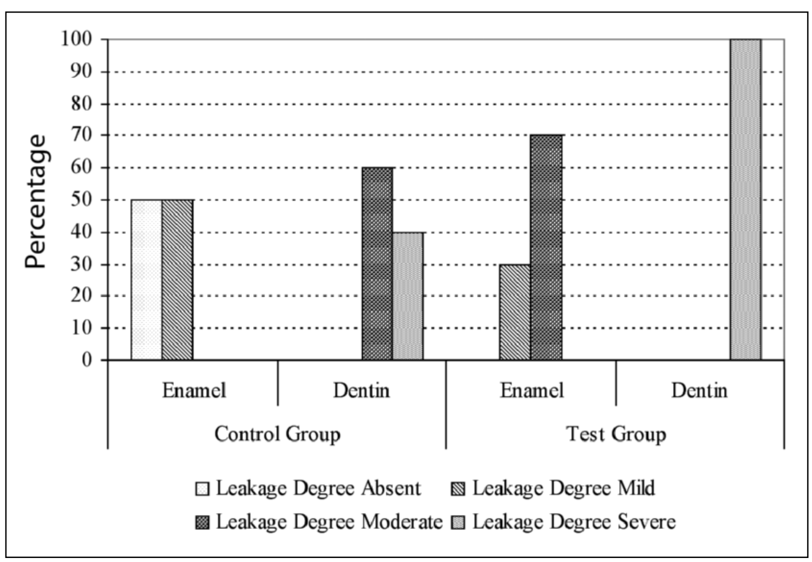

Figure 1. *The degree of microleakage in enamel and dentin using Filtek P60.*

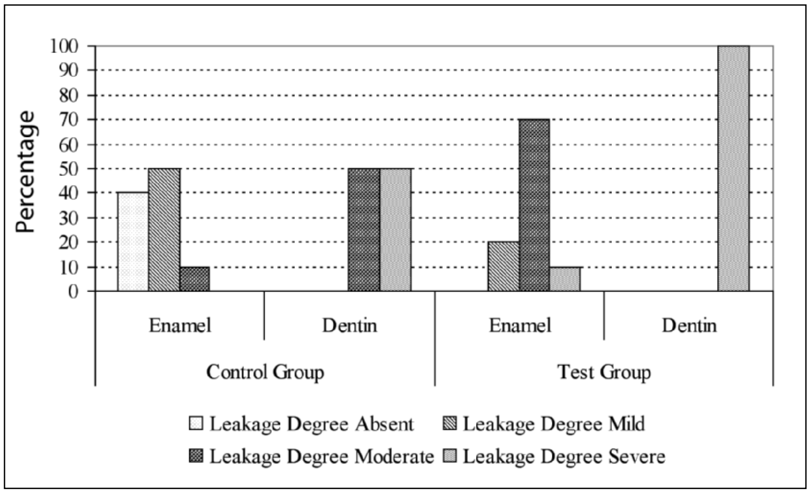

Figure 2. *The degree of microleakage in enamel and dentin using Filtek P60 + Filtek flow.*

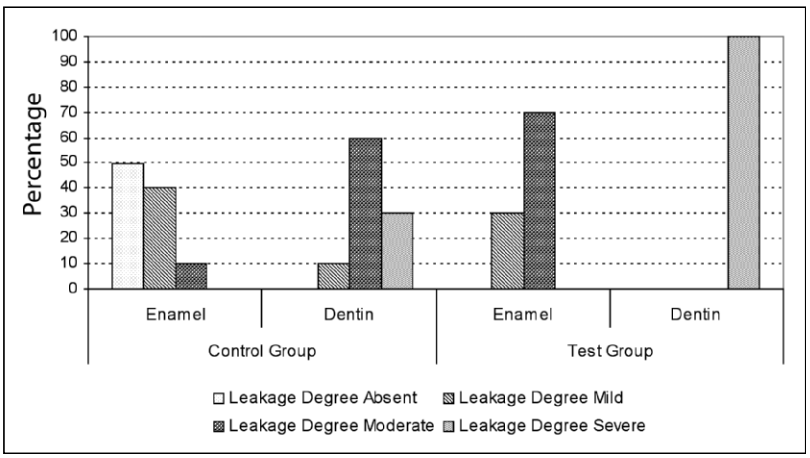

Figure 3. *The degree of microleakage in enamel and dentin using Filtek P60 + Dyract AP.*

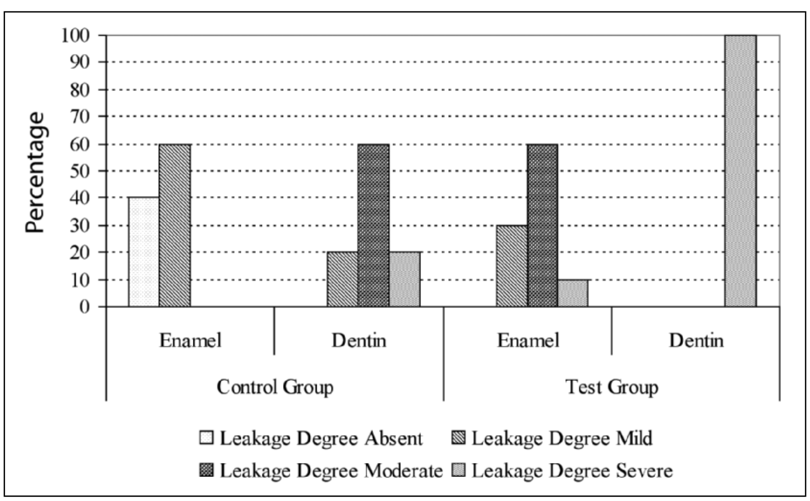

Figure 4. *The degree of microleakage in enamel and dentin using Filtek P60 + Vitremer.*

were found in both the control and test groups. Upon completion of the paired comparison of the control and test groups, a significant statistical difference was found in the level of enamel (Mann-Whitney test, $p<0.05$). A statistically significant difference was not found for the flow material group in dentin. For enamel and dentin, the Kruskal-Wallis test did not detect any statistically significant difference in the amount of leakage among the four studied materials, with a 5% level of significance.

DISCUSSION

The results from this study agree with the published literature—margins located in dentin allow for a greater rate of microleakage when compared to margins in enamel. However, just like the results found by Campos and others,[7] the values found in enamel before and after occlusal loading were unfavorable, as many studies[14-16] have demonstrated excellent microleakage results in enamel. These results were not found in the current study. The methods used in this study were based on those used by Campos and others,[7] as there was a desire to compare the results from this study with that of the first study. As a result, the current study employed a microleakage evaluation method that is already a known methodology used by many researchers. In the study by Campos and others,[7] the authors also compared microleakage with and without occlusal loading. Since the results in enamel from that study were unfavorable, even without occlusal loading, it was decided to change the packable composite in the current study from Surefill to Filtek P60. However, Figure 1 shows that there is still microleakage in 50% of the enamel specimens. Some parameters, such as polymerization contraction, light curing speed and intensity, the elastic modulus of the packable composite and the aprismatic or anizotropic structure of enamel in the cervical region, may be responsible for these results.

Studies done by Takamizu and others,[17] Sakaguchi, Douglas and Peters[18] and Feilzer and others[19] report that polymerization speed is directly related to the composite's visco-elasticity property. As a result, with polymerization contraction, greater light intensity will result in less viscosity, which, in turn, leads to greater composite contraction. In order to reduce the composite contraction effect, if light intensity could be reduced, the contraction effect will diminish. However, according to Peutzfeldt,[20] the degree of composite conversion will also be diminished, thus reducing the material's mechanical properties. Although Hansen and Asmussen[21] do not consider there to be a direct relation between light intensity and composite mechanical properties, authors, including Rueggeberg, Caughman and Curtis[22] and Rueggeberg and Jordan,[23] have suggested that, due to this composite resistance reduction, and considering the intensity decrease, polymerization time should be increased. Additionally, according to studies by Goracci, Mori and Martinis[24] and Koran and Kürschner,[25] equipment producing gradual photopolymerization should be used, thus alternating low frequency with high frequency. However, Yearn[26] considers that, as layers closer to the surface acquire maximum polymerization, it would be very difficult to extend photopolymerization to the deeper layers by increasing exposure time, as it would be very difficult to have light reach those layers. The same author states that the light source should be located as near as possible to the material being applied. In their studies, Davidson and de Gee,[27] Feilzer, de Gee and Davidson[28] and Carvalho and others[29] observed the direct relation between polymerization contraction and the cavitary configuration factor. They also noted that the greater the number of walls related to the composite, the greater the stress generated during the reaction, resulting in greater polymerization contraction, which would take to an opening of the tooth restoration interface.

A study by Bouschlicher, Vargas and Boyer[30] demonstrated that packable composites develop great stress during polymerization contraction due to a reduction of the viscoelasticity property. This is relevant, since a probable improvement in performance composites automodule elasticity is observed in studies done by Tung and others.[15] These studies showed that improvements in cervical adaptation are observed when low-module elasticity resin materials are used as a lining for packable composites between the hybrid layer and the more rigid restorative composite, probably due to reducing the stress generated during polymerization. Other authors[8-9] have decreased the amount of microleakage in cervical walls by including a first increment of flowable composite or reinforced light-curing glass-ionomer before applying a packable composite. Based on these studies, the authors of this study decided to use a first layer of flowable composite, light-curing glass-ionomer or compomer. However, as shown in Figures 1 through 4, significant differences among subgroups were not found. In fact, if all the figures are compared without statistical analysis, the best results in enamel were found in the first subgroup, where the packable composite was used alone and, for dentin, the best results were found in the last subgroup (Filtek P60 + Vitremer). This could indicate the use of Vitremer with Filtek P60 in cases where the cervical wall is located in dentin and, when the cervical wall is located in enamel, the use of a packable composite alone. However, statistical analysis showed that the enamel and dentin subgroups were similar, which indicates that all the materials allowed for the same amount of leakage.

The occlusal loading effect had a negative influence, altering the degree of microleakage according to studies by Mandras, Retief and Russel,[31] Lundin and Norén[32] and Campos and others.[7] These studies showed that samples submitted to occlusal loading had a greater microleakage rate when compared to the control groups. Thus, it can be considered that loads on the occlusal surface of samples may promote cusp deflection, producing stress next to the margins, causing an opening at the tooth/filling interface that facilitates dye leakage and, consequently, microleakage. When adhesion of the tooth/filling is analyzed, depending on the strength, intensity and duration of loading, this bond might break-off, facilitating still more microleakage.

Results after occlusal loading in enamel and dentin, as shown in Figures 1 through 4, are cause for concern, as severe microleakage was found in all specimens. This means that periodical supervision of proximal packable composite restorations is necessary and essential, as microleakage greatly increases after mechanical load incidence, even when this material is associated with other materials, such as a flowable composite, glass-ionomer or compomer. In fact, such restorations are a prescription for failure and should be clinically avoided.

CONCLUSIONS

Based on the data collected, restorations with margins located in dentin had a greater degree of microleakage than those located in enamel. When the samples were submitted to occlusal loading, the restorations were negatively influenced, increasing microleakage scores in enamel and dentin. No statistically significant difference was found when comparing the four tested materials to each other.

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