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A microleakage comparative study for indirect composite restorations on posterior teeth

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This study used a quantitative method to assess microleakage at the tooth–restoration interface in relation with the type of indirect resin-based composite used. Forty standardized class II cavities for inlays were prepared in 20 previously extracted, sound permanent third molars. Teeth were randomly divided into 2 groups (n=20) and restored with composite inlays using the Gradia (GC Corporation, Japan) and Barodent composite (Institute for Research in Chemistry, Romania). Composite inlays were prepared by the indirect technique; they were built up on models after cavity impressions according to the manufacturer's instructions. All inlays were luted using self-adhesive dual cured resin cement (G-Cem/GC Corp). Microleakage testing was done by immersing the restored teeth in 2% methylene blue solution for 24 hours. Dye penetration at gingival and occlusal margin, along the tooth-cement interface was evaluated using an inverted microscope (Olympus KC301, Olympus America Inc.) at 40x magnification. Dye penetration values were recorded (µm) using QuickPhoto Micro 2.2 software (Olympus Inc) and data were subjected to statistical analysis. No significant differences regarding microleakage in dentin and enamel were observed between the analysed groups ($p<0.05$). Significant differences between the enamel and dentin interface was observed within the same group.

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1. Introduction

The main objective of restorative dentistry is to restore the anatomy and function of carious or traumatically damaged teeth. In present, when the patients' aesthetic demands are constantly growing, the contemporary restorative techniques are based on the use of composite resins. These are considered to be the material of choice for morphological and biomechanical restorations of the teeth because of their elastic modulus similar to the dental tissues and because of their ability to bond to enamel and dentin [1-4].

The characteristics of these advanced materials when associated with adhesive systems have created technical alternatives within the restorative techniques, thus increasing the use of aesthetic restorations.

Even though the contemporary composite resins offer many advantages for the practitioner and also for the patient, these materials still present problems related to the marginal integrity and leakage, mostly due to their inherent polymerisation shrinkage [5-7].

The durability of direct and indirect composite restorations depends on the quality of their marginal and internal adaptation [8].

In order to achieve and maintain the integrity of the tooth-restoration interface, composite materials continued to develop with the improvement in inorganic filler (amount, type and average size) and the improvement in the molecular weight of monomers that compose the organic matrix, thus enhancing their properties and making them easier to manipulate and apply [5].

Barodent is a composite material, manufactured by the Institute for Research in Chemistry, Romania used for indirect restorations. It contains a Bis-GMA based resin matrix and inorganic filler represented by a mixture of barium glass (50%), colloidal silica (20%) and quartz (30%).

All restorations have to assure a hermetic interface that must resist to dimensional changes in time, in order to prevent infiltration of fluids, bacteria, molecules and ions [9]. Microleakage is the primary cause for post-operative sensitivity, pulpal inflammation and restoration failure [8,10].

There are many *in vitro* methods used to evaluate the marginal adaptation of restorations, such as the use of organic colorants, chemical markers, radioactive isotopes, bacteria, and microscopic study of the tooth-restoration interface [1].

The most frequently used method for microleakage observation *in vitro*, is represented by immersion in colorant solutions, as methylene blue 2% or silver nitrate 50% [1,11] and scoring of dye penetration through a semiquantitative method. In this study we developed a quantitative method to assess microleakage at the tooth–restoration interface in relation with the type of indirect resin-based composite used.

2. Experimental

Forty standardized class II cavities for inlays were prepared in 20 previously extracted, sound permanent third molars. All the cavities had the following characteristics: 3 mm in buccolingual width, 5-6 mm occlusal-cervical height, 2 mm depth; the gingival margin placed at 1 mm below the cemento-enamel junction. All vertical walls were prepared divergent toward the occlusal site (5-15°), all inner angles were rounded. No bevels were placed at any of the margins of the cavities and all margins and cavity walls were smoothed.

Teeth were randomly divided into 2 groups (n=20) and restored following manufacturer's instructions, as follows: Group 1 with indirect light-cured composite Gradia (GC Corp, Tokyo, Japan), and Group 2 with light-cured, post cured with heat and pressure indirect composite Barodent (ICCRR, Romania).

Composite inlays were prepared using the indirect technique, following the manufacturer's instructions. Impressions were made from each cavity preparation using the wash technique with two different viscosities addition silicones (Aquasil Soft Putty and Aquasil Ultra LV/Dentsply Caulk, USA). Dies were fabricated using IV type die stone (Fuji Rock/ GC Europe, Leuven, Belgium).

Composite inlays were prepared by applying the resin in approximately 2 mm width layers, followed by light curing using the Steplight SL-1 unit (GC Corp) according to the manufacturer's instructions. Gradia inlays were submitted to a final polymerisation using the Labolight LV-III unit (GC Corp) for 3 minutes, while the Barodent inlays were post-cured at 135°C and 60 psi in nitrogen atmosphere (BelleGlass HP Curing Unit/ Kerr Corporation, Orange, USA).

The composite inlays were luted using the self-adhesive dual-cured resin cement, G-Cem (GC Corp, Tokyo, Japan).

The internal surfaces of composite inlays were treated with 50 µm aluminium-oxide particles, then silanated with a thin layer of Composite Primer/GC and polymerised for 20 seconds with the LED curing unit G-Light/ GC. Teeth cavities were washed and gently dried, keeping them moist.

The luting cement was applied using the GC Capsule Applier directly onto the internal surface of the inlays. The inlays were placed into the cavities and maintained in place under moderate pressure until the resin cement felt rubbery, the excess cement was removed, and then the restorations were light cured for about 10 seconds on each surface using the G-Light unit.

After finishing and polishing all restorations, the restored teeth were kept in distilled water at 37°C for 24 hours. Teeth were then subjected to thermocycling for 2000 cycles (MJ Minicycler), between 5°C and 55°C with a dwell time of 30 seconds and a transfer rate of 10 seconds between each bath.

The entire surface of each tooth was coated with two layers of varnish, except for a 1 mm width around the margins of the restorations. The teeth were immersed in a 2% methylene blue solution for 24 hours then rinsed for about 10 minutes in running water.

They were sectioned in the mesio-distal direction using a low speed diamond saw (Isomet, Buehler Ltd.) resulting one section of 1mm width in the middle of the restoration. Dye penetration at gingival margin, along the tooth-cement interface was evaluated with an inverted microscope (Olympus KC301, Olympus America Inc.) at 40x magnification and microleakage values recorded (µm) using a QuickPhoto Micro 2.2 software (Olympus Inc). For each interface microleakage values were referred to the total length of that interface. Data were subjected to statistical analysis by Student test at a $p<0.05$ level of significance using SPSS 13.0 software.

3. Results

The optical microscopy showed dye penetration (green line) along the tooth-resin cement interface for both types of composite inlays (Fig. 1-2).

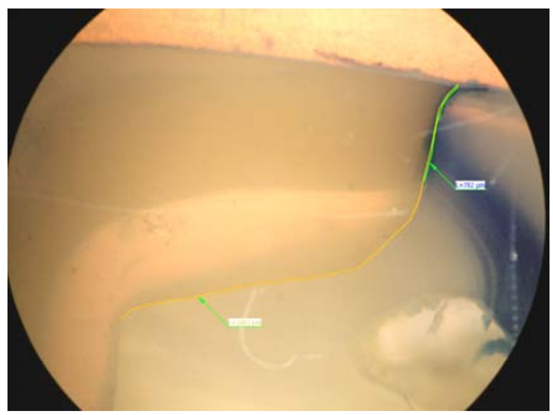

Fig. 1. Dye penetration measurement (green line), along the tooth-restoration interface (orange line) for Gradia inlays.

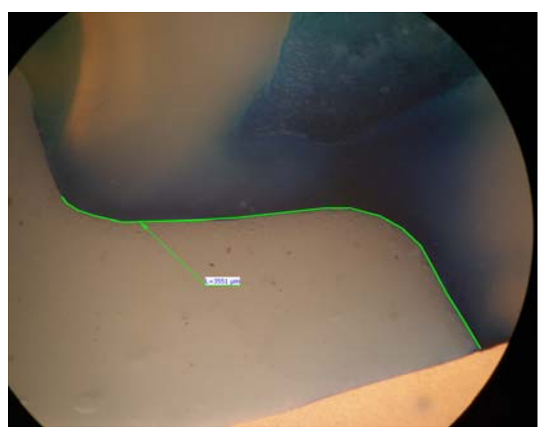

Fig. 2. Dye penetration measurement (green line), along the tooth-restoration interface for Barodent inlays.

Dye penetration values for the two groups related to the tooth interface length are shown in Table 1.

Table 1. Mean values for proportion between dye penetration and interface length.

	Group	Average	Standard Deviation	p
Proportion microleakage/tooth interface length in dentin	1	0.36	0.35	0.72
	2	0.40	0.35	
Proportion microleakage/tooth interface length in enamel	1	0.07	0.10	0.38
	2	0.10	0.09	
Proportion microleakage/ tooth interface for Group 1	dentin	0.36	0.35	0.003
	enamel	0.07	0.10	
Proportion microleakage/ tooth interface for Group 2	dentin	0.40	0.35	0.001
	enamel	0.10	0.09	

The Student test disclosed no significant differences regarding microleakage in dentin between Group 1 (0,36±0,35) and Group 2 (0,40±0,35) (p=0,72). Both groups performed similar at the enamel margin (p=0,38). However, statistically significant differences were observed within the same group between the enamel and the dentin interfaces: Group 1 (p=0,003) with proportion values for enamel (0,07±0,10) and for dentin (0,36±0,35); Group 2 (p=0,001) with the proportion values for enamel (0,10±0,09) and for dentin (0,40±0,35) (Fig. 3).

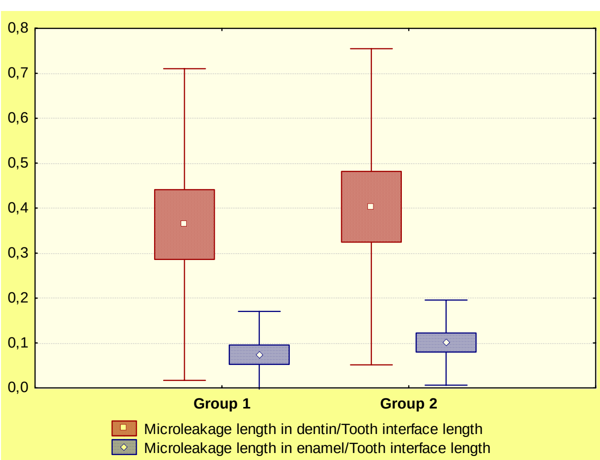

Fig.3. Proportion of microleakage in dentin and enamel/ tooth interface length

4. Discussion

Polymerisation shrinkage remains an important shortcoming of composite restorations, leading to bonding failure with gap formation. Microleakage at this interface could lead to marginal staining, postoperative sensitivity and secondary caries [12].

In the case of composite inlays shrinkage is limited to the luting space that could reduce the negative effects at the interface. Post-curing with heat and pressure increases the degree of conversion improving the mechanical properties of the composite and thus the wear resistance of the materials.

In vitro testing of new and improved materials remains an important method to evaluate the qualities of dental material and represents an indicator for the possible leakage that may or may not occur in vivo [1,13].

In this study a quantitative method was used to evaluate microleakage at tooth-resin cement interface for two different indirect composite systems. Measurement involved the length of dye penetration related to the entire length of the bonded interface.

Both materials used exhibited some degree of microleakage, these findings being in agreement with other studies [1, 14, 15].

There are many factors that may influence polymerisation shrinkage and the adaptation of composite inlays: adhesive/resin cement combinations and their ability to withstand the interfacial stress, the ability of the indirect restorations to deform during the resin cement polymerisation, internal gap size and consequently interfacial cement volume [12, 16].

In this study a self-adhesive dual-cured resin cement was used (G-Cem/GC Corp) based on functional monomers as 4-MET and phosphoric acid ester, with smaller dimensional changes.

Even though the two systems used in this study have different compositions and curing mechanisms, that may influence their marginal and internal adaptation, they achieved a similar sealing ability both for dentin (p=0.72) and enamel (p=0.38). In same time, both groups performed better at the enamel-cement interface than at the dentin-cement one (Group 1 p=0,003; Group 2 p=0,001).

Within these, we may assume that the luting cement is the main responsible for these results. The luting cements are the bond between the dental tissues and the indirect restorations, so their capacity of sealing this interface is crucial for the longevity of the inlays.

Self-adhesive cements are less technique sensitive, but according to the literature, they don't act as good as conventional dual cured resin cements, because the conditioning step is missing [12]. This may be an explanation for dye penetration in enamel margins (Group 1 =0,07; Group2 =0,10), where conditioning step is very important in order to obtain qualitative hybrid layers.

On the other hand due to the difference in thermal expansion between the tooth and luting agent, the thermal cycling of an inlay restoration between high and low temperatures may cause a rupture of the bond between the tooth and the luting agent [17]. The weaker the bond first is, the higher microleakage will be observed after thermal cycling. This may be the explanation for the differences we revealed between the enamel and the dentin interfaces for both groups.

5. Conclusions

Within the limitation of the study design the following conclusions may be drawn:

- The two indirect composite systems investigated have similar behaviour regarding dye penetration in dentin and enamel.

- Less microleakage was observed in enamel than dentin for both examined groups with the use of the self-adhesive resin cement.

- The use of self-adhesive resin cements in luting composite inlays does not achieve a perfect marginal and internal adaptation.

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