Abstract

The purpose of this study was gingival border tightness assessment of class II composite resin restorations, after the use of 4 different material insertion methods. Material and method The study included 20 human posterior (PM and M3) whole teeth, which were removed from various reasons; limited proximal-occlusal cavities, standardized from the location and size standpoints, were prepared on both proximal faces. The restorations were done using the same material, that is Filtek Supreme XT (from 3M ESPE), and the Adper Easy One Bond Self-Etch Adhesive (from 3M ESPE), the specimens being distinguished depending on the material insertion method employed and classified in 4 study groups: group A: bulk technique, group B: horizontal layering technique, group C: oblique layering technique and group D: centripetal buildup technique. The specimens underwent a 10% methylene blue staining process, subsequent to restoration edge sealing using nail polish. Stain penetration assessment was done after 4 distance setting procedures; the results were then statistically processed by means of the $\chi^2$ test, employed to determine the existing correlations between the technique used and the percolation achieved. Results The first (A – bulk) method had strong correlations with the 3rd degree percolation and with type 2 + 3 percolations. Method C showed correlations with 0 and 0 +1 percolations. Conclusions None of these insertion methods provided perfect sealing of the gingival border; however the best method was the oblique layering technique.

Key words: composite resin restorations, marginal micro-percolation, insertion technique

Introduction

Tooth decay still has a prevalence of 91.09% and a 7.7 DMFT index in the 36-64 age group in Romania. Unfortunately, even caries distribution according to severity is completely unfavorable, as 14% of the cavities (enamel cavities) were in the D2 stage, and 36% (dentinal cavities) were in the D3 stage

Nowadays, the main therapeutic objective in caries management is the prevention of new caries and the early detection of existing ones, so as to treat them and stop their evolution only through non-operative preventive/therapeutic means. The D2 and D3 stages enjoy however only a restorative treatment under the cover of preventive/therapeutic measures, and therefore the need for restorative treatment has been increasingly higher in our country.

These last few decades, composite resins have established themselves as the most common restorative therapy for posterior aproximal caries, due to their good aesthetic appearance, to the fact that they prevent the controversial use of mercury in Ag amalgam filling, to the fact that they are good thermal insulators and thanks to the adhesive systems employed they adhere to hard dental tissues.

However, there has been noticed that with time the use of composite resins in the posterior teeth had several inconveniences: high polymerization shrinkage, post-operative dental sensitivity and a lower strength then expected to occlusal forces.

The high stresses occurring at the tooth/restoration interface, caused by the composite resin polymerization shrinkage (1-3% in volume),
lead in time to the loss of restoration tightness and the occurrence of marginal percolation. If enamel adhesion proved satisfactory and long lasting, the dentine and cement data gathered did not prove a similar sealing power, which got poorer with time.

The loss of gingival border sealing may cause bacteria infiltration, recurrent caries, marginal stain, pulp inflammations and post-operative dental sensitivity.

Here are several factors significantly influencing stress effects further to polymerization shrinkage: cavity volume reduction through minimally invasive procedures, photopolymerization technique, C (configuration) cavity factor modification, organic resin content of the restoration material and its insertion into cavity method.

The purpose of this study was gingival border tightness assessment of class II composite resin restorations, after the use of 4 different material insertion methods.

**Material and method**

The study included 20 human posterior (PM and M3) whole teeth, which were removed from various reasons: orthodontic, periodontal or prophylactic reasons.

Immediately after their extraction, they underwent a thorough scaling and cleaning process, all the organic remains were removed by means of periodontal curettes and they were brushed off with prophylaxis brushes and proper paste.

Before the beginning of the trial all the teeth were kept in physiological saline and 12 hours before their processing they were immersed in formalin.

Each group was inserted into a Duracryl heat-polymerized acrylic bar (manufactured by Spofa) in order to seal the apexes and to create a support for the metal matrixes used to recover the functional morphology of proximal surfaces. The apexes were initially inserted into wax bars, 2 mm from the enamel-cement junction; they were packaged, forming a mould where the acrylic was inserted. The polymerization reaction took place at the temperature and pressure indicated by the manufacturer. After disassembly, the acrylic was finished and polished.

Although the teeth had different sizes and shapes, we managed to perform limited occlusal-proximal cavities (LOP) on all the M and D surfaces of each tooth. The V and O walls were parallel, had a 3 mm opening, the cavities were 2 mm deep on the average, and the gingival border was located 1mm apically from the enamel-cement junction (Fig. 1).

None of the wall edges were beveled. Cavity preparation was performed after water cooling by the same no. 1157 straight round head tungsten carbide burs (manufactured by Mid West Dental Products and Brasseler USA).

For restoration we used Filtek Supreme XT nano-composite tooth filling (from 3M ESPE) and Adper Easy One Bond Self-Etch Adhesive (from 3M ESPE) (Fig. 2).

In order to standardize the gingival border adjustment technique, we used the no. 2 Ivory matrix and matrix retainer system (Carl Martin, Germany).

The 40 cavities were randomly divided into 4 study groups (A-D), according to the material insertion method employed.

Therefore, the bulk insertion technique was used on group A (n=10), as the whole restoration material was inserted in a single stage procedure, and after composite resin shaping by means of special tools (Polyfill 1051/107, Carl Martin, Germany).
We performed a 40 seconds occlusal polymerization procedure, a 20 seconds vestibular polymerization process and a 20 seconds oral polymerization procedure.

For the next 3 groups, we used subsequent layering according to different strategies. This method reduces the polymerization shrinkage effects, increases marginal adjustment, reduces percolation, decreases gap formation, decreases cuspal deflection, increases their strength to a possible subsequent fracture and decreases dental post-operative sensitivity\textsuperscript{23,24}.

In group B we used horizontal layering, where the first resin layer was laid over the gingival border and polymerized from the occlusal for 20 seconds, and then 3 more successive horizontal polymerized layers were laid in the same manner.

In group C we employed oblique feather-like layering, where the first triangular layer was laid on the vestibular half of the gingival border and on the gingival half of the vestibular wall, and then polymerized from the occlusal. The second layer, having the same shape, was placed on the lingual half of the gingival wall and on the gingival half of the lingual wall, and then polymerized from the occlusal. The third triangular layer, with its top pointing to the gingival component, was polymerized from the occlusal, and the resin layer replacing the enamel layer is placed over it.

In group D we preferred the centripetal buildup technique, where the initial vertical layer was laid over the gingival border and on the matrix wall, which turned a class II cavity into a class I one, with a significant reduction of the cavity’s C factor. We then laid 3 more horizontal layers, which were polymerized from the occlusal. Photopolymerization was achieved using the Led Demetron II device (from Kerr, USA) with a 1000 w/cm\textsuperscript{2} power.

The restorations were finished and polished after having been immersed in distilled water at constant temperature (20°C). The specimens were then dried and covered with 2 successive layers of nail polish, except for the restorations and a 1mm area around them.

After the nail polish dried, the specimens were immersed in 10% methylene blue for 48h, at a temperature of 37%. (Fig.3)
The specimens were thoroughly washed in running water and then the teeth were cut in half longitudinally, through the geometric center of the crown and restorations, by means of a fine diamond disk active on both faces.

Stain penetration was assessed by means of a Zeiss X20 microscope (from Iena, Germany) and was classified in 4 groups (0-3), according to its depth:

0 – no penetration (Fig.4)
1 – stain penetration up to the outer ½ of the gingival border (Fig.5)
2 – stain penetration throughout the whole gingival border (Fig.6)
3 – stain penetration in the axial wall as well (Fig.7)

For the statistical result analysis, we employed the \( \chi^2 \) test, designed to determine the existing correlations between the technique used and the percolation achieved.

**Results**

Further to the analysis of the study results obtained, we noticed that all 4 study groups had results matching the scale proposed as standard. (Table 1)

<table>
<thead>
<tr>
<th>Group</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (bulk)</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>B (horizontal)</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>C (oblique)</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>D (centripetal)</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1  
Stain penetration results

In group A (bulk technique), 9 specimens scored 3 in percolation and only one specimen scored 1. In group B, none of the specimens scored 0, and 5 specimens scored 3. Group C had the best results, as 7 specimens scored 0, that is no percolation, and in group D, the results were scattered throughout the scale, half of them scoring 0 in stain penetration.

The first (A – bulk) method had strong correlations with the 3rd degree percolation and with type 2+3 percolations. Method C showed correlations with 0 and 0+1 percolations. In order for the correlation to be valid, all these requirements have to be met: \( \chi^2 > 3.84 \), positive IC limits (no null hypothesis) and \( p < 0.05 \) (greens boxes). RR is the risk ratio, that is percolation occurrence likelihood. (RR = 4.5 => the percolation occurrence risk is 4.5 times higher) (Table 2)

<table>
<thead>
<tr>
<th>Group</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (bulk)</td>
<td>( \chi^2 = 14.01^* )</td>
<td>( \chi^2 = 10.28^* )</td>
</tr>
<tr>
<td></td>
<td>RR = 4.5</td>
<td>RR = 2.5</td>
</tr>
<tr>
<td></td>
<td>OR = 36.00</td>
<td>OR = 36.00</td>
</tr>
<tr>
<td></td>
<td>IC = 1.29 – 5.88</td>
<td>IC = 1.29 – 5.88</td>
</tr>
<tr>
<td></td>
<td>( p = 0.000182 )</td>
<td>( p = 0.001345 )</td>
</tr>
<tr>
<td>B (horizontal)</td>
<td>( \chi^2 = 0.56^* )</td>
<td>( \chi^2 = 3.28^* )</td>
</tr>
<tr>
<td></td>
<td>RR = 1.5</td>
<td>RR = 1.71</td>
</tr>
<tr>
<td></td>
<td>OR = 2.00</td>
<td>OR = 4.57</td>
</tr>
<tr>
<td></td>
<td>IC = -0.79 – 2.18</td>
<td>IC = -0.22 – 3.26</td>
</tr>
<tr>
<td></td>
<td>( p = 0.454177 )</td>
<td>( p = 0.070052 )</td>
</tr>
</tbody>
</table>

Table 2  
Statistical correlations in groups A and B

*for a degree of freedom, the \( \chi^2 \) limit value calculated for a confidence of 95% (\( p=0.05 \)) is \( \chi^2 = 3.84^* \) RR = risk ratio OR = odd ratio IC = interval of confidence

In all the other cases, at least one of the requirements above is not met (in red), which means no correlation can be established. (Table 3)
Table 3: Statistical correlations in groups C and D

<table>
<thead>
<tr>
<th>Group</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \chi^2 = 10.16^* )</td>
<td>( \chi^2 = 13.80^* )</td>
</tr>
<tr>
<td></td>
<td>RR = 4.2</td>
<td>RR = 3.86</td>
</tr>
<tr>
<td></td>
<td>OR = 11.67</td>
<td>OR = 29.57</td>
</tr>
<tr>
<td></td>
<td>IC = 0.76 - 4.15</td>
<td>IC = 1.1 - 5.66</td>
</tr>
<tr>
<td></td>
<td>p = 0.001436</td>
<td>p = 0.000194</td>
</tr>
</tbody>
</table>

Discussions

Proximal caries on posterior teeth require restoration treatment and, when using composite resins as filling material, the cavity should have a limited proximal-occlusal design, thus complying with the principles of minimally invasive procedures.

These restorations have a predisposition to marginal degradation of the gingival border, especially when it is under the enamel-cement junction. Here are some of the factors responsible for a poorer adhesion of composite resins to dentine then to enamel: tube-like structure, high organic matter content, existence of dentinal fluid with extravasation properties, a higher permeability and a lower surface energy.

A clinical study assessing the quality of gingival edges of class II composite resin restorations showed that only 27% of them are satisfactory.

The bulk technique is recommended by some authors to reduce cavity wall edge stress. Although this has not been proven by clinical studies, some manufacturers recommend this technique for condensable composite resins.

We should bear in mind that polymerization depth does not exceed 2mm even when photopolymerization is performed using state-of-the-art devices.

Bulk tooth filling is not recommended since it provides a limited polymerization depth and it increases gap formation likelihood in the restoration mass, it increases polymerization stress and exothermal reaction that may irritate the pulp.

Our study showed this technique to provide the poorest marginal sealing, 9 of the 10 specimens scoring 3, the stain reaching the parapulpal wall.

In order to prevent the disadvantages of the previous technique we proposed the layer insertion or layering method, which, according to some authors, may have several advantages: the material is polymerized in 0-2mm thick layers; thus a good marginal quality is achieved and cavity wall distortion.

There were however studies showing that this technique may cause more stresses between surfaces than the bulk technique, which means that the later successive layers do not perfectly adhere to one another.

In group B we used horizontal layering, which was said, in some studies, to have a poor gingival marginal sealing power, as the polymerization shrinkage “pulls” the material off the wall and to increase by itself the cavity C factor.

In our study, this technique proved mediocre, as in half of the specimens the stain penetration score was 3.

In order to prevent some of the disadvantages of the previous method, we proposed the oblique...
layering feather-like technique. Some authors proposed the polymerization to be done indirectly from the V and O through the enamel walls in order to direct the polymerization vectors towards the cavity walls but this study preferred polymerization from the occlusal in all the study groups. This technique proved the best in providing cervical marginal sealing, 7 specimens scoring 0 and none of them 3.

In group D, we employed the centripetal buildup technique, which, according to some authors, would have the advantage that the first (vertical) layer does not touch the parapulpal wall, the likelihood of filling shrinkage and its migration towards the edge of the gingival border is low. In this study, the value of this method is doubtful; however it is better than the first two, since 5 specimens scored 0 in stain penetration, although one specimen showed a full stain infiltration.

The results of our study agree with the results of other studies, as marginal adjustment of the gingival border located in dentine in class II composite resin restorations was influenced by the cavity filling insertion methods employed.

**Conclusions**

1. None of the insertion methods provided perfect gingival border sealing.
2. The best method was oblique layering.
3. The bulk insertion technique caused the most serious marginal percolation phenomenon.

**References**

24. Opdam NJ, Feilzer AJ, Roeters JJ, Smale I. Class I occlusal composite resin restoration: In vivo post-