Evaluation of Marginal and internal adaptation of adhesive class II restorations, in vitro fatigue tests
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Chapter 6:

Adaptation of Indirect Class II Composite Restorations with Different Resinous Bases
Aim of the study

Because of the polymerisation shrinkage of current materials (Bowen et al., 1980; Davidson et al., 1984; De Gee et al., 1993; Labella et al., 1999; Stavridakis et al., 2001) and spontaneous post-curing which takes place during several days after composite insertion (Leung et al., 1983; Kidal and Ruyter, 1994), the semi-direct or indirect techniques are the adequate alternatives to direct fillings in large cavities (Dietschi and Spreafico, 1997). In addition, large cavities often extend close or below the cemento-enamel junction, making rubber dam placement as well as cementation more complicated. The application of a base underneath semi-direct and indirect restorations therefore represents a common, non-invasive alternative to a surgical crown lengthening in order to relocate cavity margins supra-gingivally (Dietschi and Spreafico, 1998). The base also fulfills additional requirements, such as reinforcing undermined cusps, filling undercuts and providing the necessary geometry for an inlay/onlay restoration.

Functional loading and thermal cycling are additional sources of stress which further increase the risk of adhesive or cohesive failures. Therefore, waiting for further improvements in dentin bonding efficacy and reliability and a significant reduction of composite polymerization shrinkage, efforts have also to be made to favour all sorts of compensatory phenomena (Bowen et al., 1983; Davidson et al., 1984; Davidson, 1994; Carvahlo et al., 1996). The elastic modulus (E) of the restorative material, among other physical properties, is of main importance to evaluate their potential stress absorbing effect (Lutz et al., 1986; Friedl et al., 1997). Actually, depending on the material’s stiffness and deformation capability, stress within the adhesive interface can be lowered (elastic modulus lower or matching the one of surrounding structures) or just passed on the next interface without absorption (high elastic modulus). The ideal E-modulus of a base material remains to be established.

In indirect restorations, the bond strength between the resinous base and luting composite and between the luting composite and inlay, resulting from micro-mechanical retentions or copolymerisation, was found to be critical (Scott et al., 1992; Krejci et al., 1994), especially after restoration post-curing. If this interface would be a weak component of the restoration, it might have significant consequences. For the time being, however, a significant rate or even occasional debonding or loss of adhesively luted restorations, was never documented.

The aim of this in vitro study was to test the hypothesis that the elastic module of resinous bases can influence the marginal and internal adaptation of class II indirect composite restorations, after simulated occlusal fatigue loading. Attention was also paid to the quality of the different interfaces, in order to identify the restoration’s most vulnerable areas.
Specific Materials & Method

Specimen preparation

Box-shaped Class II cavities (MOD) with tapered walls and no bevel were prepared, with proximal margins located 1.0 mm below (mesially) and above (distally) the cementum-enamel junction, such as described in chapter 2 (Fig. 2.5B). The 40 prepared teeth were randomly assigned to the control group (no base) or one of the 4 experimental groups with different base materials: Revolution (Kerr; Orange, CA, USA) (REVO), Tetric Flow (Vivadent; Schaan, Liechtenstein) (TFLOW), Dyract (DeTrey-Dentsply; Constance, Germany) (DYRA) and Prodigy (Kerr) (PRODI). The characteristics and references of these materials are summarised in Table 6.1.

Restorative procedures

The same restorative, luting composite material and multi-functional adhesive were used for all groups (Herculite, Nexus and Optibond FL; Kerr).

After completion of the preparation, enamel was selectively etched for 20 s prior to a 10 s full cavity etching. The cavity was thoroughly rinsed for 30 s and gently air dried (3 s air spray) so that conditioned dentin was kept slightly moist. The primer and adhesive (Optibond FL) were then placed, according to the manufacturer’s instructions. The bonding resin was light-cured for 40 s. Except for the control group specimens (CTRL), a base material was applied in order to create a layer of approximately 1 mm using a transparent matrix; the base extended to the cavity margins on both sides (Fig. 6.1 and 6.2). The material was light-cured for 60 s. The light-curing unit (Visilux XL 3000; 3M, St. Paul, MN, USA), equipped with a new bulb, had an illumination intensity of 525 mW/cm².

The base materials under evaluation are two flowable micro-hybrid composites (Revolution and Tetric Flow), a compomer (Dyract) and one restorative composite (Prodigy). In the control group, dentin and enamel surfaces were only covered by OptiBond FL. Material characteristics and group description are given in Table 6.1A-C.

After base application, cavity margins were refined again with fine diamond burs (Cerinlay No 3025.018 FG), and impressions were made with an irreversible hydrocolloid (alginate) impression material (Blueprint Cremix; DeTrey Dentsply). Hard stone (Fujirock; Fuji) individual dies were prepared. A very thin layer of wax was placed on each die as an isolation medium but without covering preparation margins. All inlays were made with the same micro-hybrid composite (Herculite enamel, shade A2; Kerr). The inlays were also submitted to a photo-thermal treatment (T = 110°C) for 7 min in a post-curing unit (D.I 500 oven; Coltène, Alstätten, Switzerland). The internal surfaces of the inlays were sandblasted with 50 µm aluminium oxide at a 2 bar pressure.
Before adhesive cementation, prepared teeth were kept for 1 wk in a water-saturated atmosphere. Then, cavities were again acid-etched for 30 s to condition enamel margins and to remove any residual contaminant from the cavity surfaces.

The 3 components of the Nexus adhesive (Kerr) were applied to all surfaces of the preparation, and the inlays were cemented following usual procedures, respecting a 1:1 ratio for the luting composite base and catalyst (Nexus). Each restoration surface was light-cured for 60 s. Restorations were immediately finished and polished with flame and pear-shape fine diamonds burs (40, then 25 μm grain size) (Intensiv No 4205L, 4255, 5205L and 5255) and discs (Pop On XT; 3M, St. Paul, MN, USA).

Mechanical loading was applied such as described in chapter 2 (Figs. 2.1-2.4). The standardized preparation of specimen for SEM evaluation, detailed in chapter 2; Figs. 2.6-2.10), was applied to all samples for the marginal and internal adaptation evaluation. In addition to the standard evaluation method for marginal and internal adaptation, two internal sections of each group were further polished to a high gloss (wet-sanding up to a 4,000-grit SiC sandpaper; LaboPol-II, Struers). After etching the surface for 30 s with 1% HCl, samples were immersed in hexamethyldisilazane (Merck, Darmstadt, Germany) for 10 min (Perdigao et al, 1995). Thereafter, samples were placed on a filter paper, inside a covered glass vial and air-dried at room temperature for 24h (Perdigao et al, 1995). Sections were then gold-sputtered for a direct SEM observation of adhesive interfaces at higher magnifications (x300 to x3,000). An attempt was made to identify the different adhesive interface components and to confirm the localisation of failures as observed on standard replicas.

Statistics

All results were submitted to a non-parametric statistical analysis. The Kruskall Wallis and Nemenyi tests (Sachs, 1974) served for comparing the restorative methods. The Friedman and Wilcoxon tests (Sachs, 1974) served for evaluating the influence of the number of cycles on the marginal adaptation. All tests were carried out at a 1% or 5% level of significance.

Results

Marginal adaptation

The percentages of "over-filled" and "under-filled" margins presented insignificant values; these results are therefore not reported. Mean percentages of "marginal tooth fracture" and "marginal opening" before and after the different loading phases are reported in Figs. 6.2 and 6.3, and in Table 6.11, together with their statistical analysis.

Regarding pre-loading marginal adaptation, samples with a Dyract base (DYRA) showed higher percentages of marginal tooth fracture compared to samples without base (CTRL).
Otherwise, no significant difference was revealed concerning restoration marginal adaptation to enamel or dentin after further loading phases.

In all groups, marginal tooth fractures (or fissures) were present in enamel before the fatigue test (12.7% (CTRL) to 25.9% (DYRA)) (Fig. 6.4). The proportion of these defects progressively increased, due to mechanical loading ((2.5% (CTRL 250,000 cycles) to 37.6% (PRODI 10^6 cycles)). In dentin, the initial percentages of marginal opening were low (1.35% (CTRL) to 13.45% (PRODI)) and then also increased significantly following mechanical stresses (4.4% (CTRL 250,000 cycles) to 30.1% (PRODI 10^6 cycles)). Although not significantly different from other groups, TFLO and CTRL exhibited the lowest percentages of marginal opening in dentin, throughout the test.

**Internal adaptation**

Mean percentages of “interfacial opening” between the restoration (inlay or base) and cavity walls after the stress test are reported in Fig. 6.5, and in Table 6.111, together with the statistical analysis exploring differences between groups and areas.

Nearly no debonding occurred between the base and luting composite or between the luting composite and the restoration; therefore, no result is provided regarding these interfaces.

The evaluation of internal adhesive interfaces showed scores of total “interfacial opening” comparable to those obtained for marginal adaptation (11.1% (TFLO) to 28.15% (PRODI)). In some dentin areas (gingival and occlusal) as well as for the total dentin area, PRODI samples showed statistically more interfacial gaps than the CTRL, TFLO and DYRA groups. The internal adaptation to dentin showed only one statistical difference between areas, in the CTRL group, where adaptation to dentin axial walls proved worse than in gingival areas with enamel.

**Micro-morphological observations of internal interfaces**

The most common observation was that debonding predominantly took place at the top of the acid resistant layer, considered as the hybrid layer (Figs. 6.6 and 6.7). Other failure mechanisms, such as cohesive fractures in dentin, within the hybrid layer, a detachment of the hybrid layer at its base, or an absence of hybrid layer, were virtually not observed.

**Discussion**

Notwithstanding that the samples were fatigued or not, this trial revealed clearly again that enamel at butt margins with enamel prisms cut parallel to their long axis are prone to fracturing. This is in accordance with the literature (Munechika et al, 1984; Carvahlo et al, 2000). It has to be emphasized that such enamel fracturing is typical of in vitro tests conducted.
with mechanical loading when cavity margins have a butt design (Krejci et al, 1993; Dietschi and Herzfeld, 1998; Dietschi and Moor, 1999) but are rarely observed in the absence of a fatigue test (Dietschi et al, 1995). However, no study has yet demonstrated the clinical importance of this problem in adhesively luted restorations.

The incidence of gap formation at dentin margins was minimal for the control and Tetric flow base groups but not significantly different from the other groups. Internal adaptation also proved satisfactory with proportions of gaps within the same range as for marginal adaptation. When considering the whole dentin interface, the gingival and occlusal interfaces, the internal adaptation proved less satisfactory for samples with a base of Prodigy. The samples with no base or having a base made of a material with an intermediate rigidity, such as a flowable composite (Tetric flow) or compomer (Dyract), showed less defects initially (CTRL) or after mechanical loading (CTRL, DYRA and TFLO). In consideration of the overall results regarding marginal and internal quality of class II composite inlays, the use of a medium rigidity material like the flowable Tetric Flow seems ideal for use as a base underneath such restorations, when a coronal displacement of dentin or enamel proximal margins is required. Further investigations are, however, needed to determine if the less optimal results obtained with the restorative material are to be merely attributed to its higher elasticity modulus or to its different viscosity, potentially affecting its ability to wet the prepared surfaces.

In this study configuration, initial marginal adaptation likely reflects the ability of the restorative technique to limit stress development due to composite polymerization during base application and inlay cementation. Marginal adaptation, during and after mechanical loading, as well as internal adaptation, should reveal the efficiency of adhesive procedures and the restoration-base potential to absorb functional stresses. The base configuration and the material physical properties also play a significant role here.

Previous reports indicated that low elastic modulus materials have the potential to better absorb polymerization shrinkage and functional stresses, and therefore enhance direct restoration adaptation when used as a base or liner (Friedl et al, 1997; Dietschi et al, 2002). This finding can be explained by the specific physical properties of flowable composites and compomers. In vitro measurements actually showed that these materials exhibit extremely low initial E-moduli (Suh, 1997), and that it exists a linear and inverse correlation between shrinkage stress and composite E-modulus (Kemp-Scholte and Davidson, 1990 a and b). A recent study reported, however, initial linear shrinkage and contraction stresses higher for flowable composites, compared to filling materials (Stavridakis et al, 2000). Material composition plays a very important role; stress development is directly related to the degree of polymerization shrinkage and material's E-modulus. However, despite these conflicting conclusions, it can be assumed that the base-liner provides a favourable configuration factor (Feilzer et al, 1987) (small thickness, ratio bonded to unbonded surfaces close to or inferior to 1). If this is true, the
adhesive interface with the cavity floor should not sustain excessive stresses and likely remains cohesive after polymerization of this first layer. Therefore no or minimal differences should be observed in the initial base adaptation, as verified by the present results.

If a very low E-module of the base initially favours stress absorption (during application of further increments or during cementation), it will as well lead to more deformation under load, which might ultimately provoke adhesive failures. On the contrary, a rigid material (especially if more rigid than dentin) might be responsible for higher stress development within the tooth-restoration interface, due to its reduced deformation capability. What remains to be determined is the ideal base-lining elasticity module, knowing that potential materials (compomers and flowable composites) exhibit highly dissimilar physical properties. In the present experimental conditions, the flowable composite Tetric flow showed the better potential to be used underneath composite inlays. Although not significantly different, the difference in final marginal adaptation to dentin between Dyract and Tetric flow bases likely reflects a superficial degradation phenomenon around the compomer base, rather than a global change in adaptation quality and biomechanical behaviour, as shown by a similar internal adaptation.

Although the efficiency of bonding to post-cured composite is considered difficult or potentially deficient (Tam and Mc Comb, 1991; Scott et al, 1992; Krejci et al, 1994), the restoration-cement interface successfully sustained the vitro loading. The usual procedure of sandblasting the internal inlay surface and covering it with uncured bonding resin proved valuable here, at least for an inlay configuration and the products selected for this study. The present finding did not confirm the need for an additional etching procedure, considered necessary by some authors (Matsumara et al, 1995; Tirlet, 1997). As well, no debonding was observed between the base and composite cement.

The observation of the internal adhesive interface showed in most areas a well organised hybrid layer and numerous tags. Tag length varied within the normal range described in the literature (5-50µm) (Pashley, 1997). Also, the hybrid layer thickness lies within reported values in the case of phosphoric acid conditioning (3-10µm) (Nakabayashi et al, 1982). When present, debonding mostly took place between the hybrid layer and the cement. It was also predominantly observed at the transition lines between the pulpal floor and axial wall (between A and O areas), where the bonding resin layer is the thinnest. This points out again the fragility of the hybrid layer surface and its critical influence on adhesion performance (Nakabayashi et al, 1982; Van Meerbeeek et al, 1993; Pashley et al, 1994; Dietschi et al, 1995). Below a critical thickness (about 100µm) (Ruegeberg and Margeson, 1990) it is likely that the bonding resin will not fully polymerise, due to oxygen inhibition, thus precluding an optimal hybrid layer stabilization. This interface can therefore be disturbed during each of the subsequent steps, potentially reducing bond strength in these areas.
Conclusion

In the present experimental conditions, it can be concluded that the hypothesis that elasticity module and physical characteristics, in general, can be used as significant predictors of restoration quality, was not fully confirmed. Furthermore, the number of cycles (mechanical fatigue) had a detrimental influence on marginal adaptation of class II composite inlays with no base or with a base made of a flowable composite, restorative composite or compomer. Base materials with an intermediate rigidity (about 7.6 GPa) (Tetric flow and Dyract) produced the best internal adaptation, while the more rigid one (Prodigy; 11 GPa) was responsible for more interfacial defects. As regard the interface morphology, debonding took place predominantly on top of the hybrid layer; this interface was again identified as the weak link in adhesively luted restorations.
<table>
<thead>
<tr>
<th>Groups</th>
<th>Product name (manufacturer)</th>
<th>Composition</th>
<th>Batch numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>REVO</td>
<td>Revolution A3 (Kerr)</td>
<td>BisGMA, TEGDM Barium Aluminoborosilicate, Silicon dioxide</td>
<td>710266</td>
</tr>
<tr>
<td>TFLO</td>
<td>Tetric Flow A3 (Vivadent)</td>
<td>BisGMA, UDMA, TEGDMA Barium glass, Ba-Al-Fluorosilicate, Trifluorure d’Ytterbium</td>
<td>818753</td>
</tr>
<tr>
<td>DYRA</td>
<td>Dyract A3 (DeTrey Dentsply)</td>
<td>UDMA, TCB Strontium fluoro-silicate glass, Strontium fluoride</td>
<td>961016</td>
</tr>
<tr>
<td>PRODI</td>
<td>Prodigy A3 (Kerr)</td>
<td>BisGMA, TEGDM, EBADM, BHT, ODMAB Barium Aluminoborosilicate, Silicon dioxide, Titanium dioxide, Zinc oxide</td>
<td>708037</td>
</tr>
</tbody>
</table>

Table 6.1 C: Physical properties of base materials (manufacturer’s data)

<table>
<thead>
<tr>
<th>Product (manufacturer)</th>
<th>Filler content (W%/ V%)</th>
<th>E-module (Gpa)</th>
<th>Flex Module (Gpa)</th>
<th>Tural Strength (Mpa)</th>
<th>Compressive Strength (Mpa)</th>
<th>Polymerization Shrinkage (%)</th>
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</thead>
<tbody>
<tr>
<td>Revolution (Kerr)</td>
<td>55.0 / --</td>
<td>4.7</td>
<td>3.4</td>
<td>108</td>
<td>220</td>
<td>5.1</td>
</tr>
<tr>
<td>Tetric Flow (Kerr)</td>
<td>67.8 / 43.8</td>
<td>7.6</td>
<td>5.3</td>
<td>110</td>
<td>230</td>
<td>4.4</td>
</tr>
<tr>
<td>Dyract (DeTrey Dentsply)</td>
<td>72.0 / 53.0</td>
<td>7.6</td>
<td>7.4-9.7</td>
<td>97</td>
<td>245</td>
<td>2.8</td>
</tr>
<tr>
<td>Prodigy (Kerr)</td>
<td>77.0 / 57.5</td>
<td>11.0</td>
<td>10.9</td>
<td>140</td>
<td>367</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Table 6.11: Results of marginal restoration adaptation (expressed as mean percentages of "marginal tooth fracture" and "marginal opening" at the proximal enamel and dentin margins (standard deviation) (n=8 per group)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Nb of cycles</th>
<th>location</th>
<th>CTRL</th>
<th>REVO</th>
<th>TFLO</th>
<th>DYRA</th>
<th>PRODI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>Enamel</td>
<td>12.74 A, a</td>
<td>20.96 A, a, b</td>
<td>14.75 A, a, b</td>
<td>25.94 A, b</td>
<td>17.74 A, a, b</td>
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<td></td>
<td></td>
<td></td>
<td>(6.45)</td>
<td>(15.70)</td>
<td>(6.73)</td>
<td>(6.78)</td>
<td>(8.33)</td>
</tr>
<tr>
<td>250,000</td>
<td></td>
<td>Enamel</td>
<td>22.51 A, C</td>
<td>27.71 A, B</td>
<td>27.69 A, B</td>
<td>26.04 A, B</td>
<td>31.75 A, C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(9.15)</td>
<td>(10.01)</td>
<td>(10.38)</td>
<td>(6.36)</td>
<td>(11.14)</td>
</tr>
<tr>
<td>500,000</td>
<td></td>
<td>Enamel</td>
<td>27.19 B, C</td>
<td>34.33 B</td>
<td>32.56 A, B</td>
<td>31.5 A, B</td>
<td>38.98 B, C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(9.27)</td>
<td>(12.45)</td>
<td>(13.93)</td>
<td>(13.1)</td>
<td>(10.78)</td>
</tr>
<tr>
<td>1,000,000</td>
<td></td>
<td>Enamel</td>
<td>30.71 B, C</td>
<td>35.31 A, B</td>
<td>35.09 B</td>
<td>34.59 B</td>
<td>37.56 B, C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(10.89)</td>
<td>(15.25)</td>
<td>(15.86)</td>
<td>(11.37)</td>
<td>(7.77)</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>Dentin</td>
<td>1.35 A</td>
<td>4.85 A</td>
<td>2.15 A</td>
<td>3.25 A</td>
<td>13.45 A</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>(3.03)</td>
<td>(6.90)</td>
<td>(3.34)</td>
<td>(4.17)</td>
<td>(29.44)</td>
</tr>
<tr>
<td>250,000</td>
<td></td>
<td>Dentin</td>
<td>4.40 A,C</td>
<td>13.07 A, C</td>
<td>4.57 A,C</td>
<td>9.55 A, C</td>
<td>20.61 A, C</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(7.34)</td>
<td>(13.57)</td>
<td>(6.38)</td>
<td>(9.57)</td>
<td>(30.06)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(11.00)</td>
<td>(16.71)</td>
<td>(4.92)</td>
<td>(18.23)</td>
<td>(30.6)</td>
</tr>
<tr>
<td>1,000,000</td>
<td></td>
<td>Dentin</td>
<td>15.88 B</td>
<td>27.44 B</td>
<td>9.21 B, C</td>
<td>29.24 B, C</td>
<td>30.09 B, C</td>
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<td></td>
<td></td>
<td>(21.60)</td>
<td>(15.03)</td>
<td>(4.53)</td>
<td>(22.68)</td>
<td>(34.45)</td>
</tr>
</tbody>
</table>

For comparison between the number of cycles (columns), means with same capital letter are not statistically different at p=0.05 using the Friedman and Wilcoxon-Frank tests F-test. For comparison between groups (rows), means with same lower case letter are not statistically different at p=0.05 using the Kruskall Wallis and Nemenyi tests. No significant difference was found for columns or rows without letter.
Table 6.III: Internal integrity of the restorations expressed as mean percentages of gap formation (standard deviation) (n=8)

<table>
<thead>
<tr>
<th>Groups</th>
<th>CTRL</th>
<th>REVO</th>
<th>TFLO</th>
<th>DYRA</th>
<th>PRODI</th>
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<tbody>
<tr>
<td>location</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DGD</td>
<td>2.40 a, A (3.52)</td>
<td>23.31 a, b (24.64)</td>
<td>7.70 a, b (13.45)</td>
<td>6.58 a, b (11.01)</td>
<td>18.74 b (17.77)</td>
</tr>
<tr>
<td>MGD</td>
<td>12.49 A, B (16.62)</td>
<td>16.09 (23.52)</td>
<td>11.06 (15.37)</td>
<td>18.69 (20.45)</td>
<td>27.86 (26.27)</td>
</tr>
<tr>
<td>AD</td>
<td>17.39 B (10.96)</td>
<td>26.30 (18.21)</td>
<td>14.98 (9.62)</td>
<td>12.91 (8.83)</td>
<td>28.88 (13.34)</td>
</tr>
<tr>
<td>OD</td>
<td>6.80 a, A, B (5.00)</td>
<td>9.95 a, b, c (8.07)</td>
<td>7.09 a, b (6.78)</td>
<td>7.84 a, b, c (6.29)</td>
<td>28.34 c (18.78)</td>
</tr>
<tr>
<td>Total</td>
<td>12.54 a, b (7.10)</td>
<td>18.91 a, b, c (13.18)</td>
<td>11.06 b (7.33)</td>
<td>11.29 b (5.12)</td>
<td>28.15 a, c (13.40)</td>
</tr>
</tbody>
</table>

**Table legend:**
- **DGD** = distal gingival dentin, **MGD** = mesial gingival dentin, **AD** = axial dentin, **OD** = occlusal dentin, **Total** = whole dentin interface.
- Means with same lower case letter are not statistically different at p=0.05 using the Kruskall Wallis and Nemenyi tests.
- Means with same capital letter are not statistically different at p=0.05 using the Kruskall Wallis and Nemenyi tests.
- No significant difference was found for rows and columns without letter.

**Notes:**
- For comparison between products (rows), means with same lower case letter are not statistically different at p=0.05 using the Kruskall Wallis and Nemenyi tests.
- For comparison between locations (columns), means with same capital letter are not statistically different at p=0.05 using the Kruskall Wallis and Nemenyi tests.
- No significant difference was found for rows and columns without letter.
Figure 6.1: Diagrammatic representation of the restoration and base configurations

- Composite Inlay
- Composite cement
- Resinous base
Figure 6.2: Results of the marginal adaptation in enamel (% of marginal tooth fractures ± SD)

Figure 6.3: Results of the marginal adaptation in dentin (% of marginal opening ± SD)
Figure 6.4: Results of the internal adaptation in dentin (% of gap formation ± SD)

Figure 6.5: SEM microphotograph of composite restoration with compomer base. Marginal tooth microfracture was the only defect observed at enamel margins (b = base; e = enamel; mf = marginal fracture)
Figure 6.6: SEM microphotograph showing the typical appearance of the adhesive interface, with a well organized hybrid layer and numerous resin tags (section of a sample with a Prodigy base; original magnification 1398x) b = base; d = dentin; hi = hybrid layer; t = resin tags

Figure 6.7-: SEM microphotograph of an adhesive failure. The separation over the hybrid layer is clearly visible; it represents the main failure mode observed underneath adhesive class II restorations. (section of a sample with a Prodigy base; original magnification 2000x) b = base; d = dentin; hi = hybrid layer; t = resin tags.
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