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18-year survival of posterior composite resin restorations with and without glass ionomer cement as base

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\textbf{A B S T R A C T}

Objective. Advantages and disadvantages of using intermediate layers underneath resin-composite restorations have been presented under different perspectives. Yet, few long-term clinical studies evaluated the effect of glass-ionomer bases on restoration survival. The present study investigated the influence of glass-ionomer-cement base in survival of posterior composite restorations, compared to restorations without base.

Methods. Original datasets of one dental practice were used to retrieve data retrospectively. The presence or absence of an intermediate layer of glass-ionomer-cement was the main factor under analysis, considering survival, annual failure rate and types of failure as outcomes. Other investigated factors were: patient gender, jaw, tooth, number of restored surfaces and composite. Statistical analysis was performed using Fisher’s exact test, Kaplan–Meier method and multivariate Cox-regression.

Results. In total 632 restorations in 97 patients were investigated. Annual failure rates percentages up to 18-years were 1.9% and 2.1% for restorations with and without base, respectively. In restorations with glass-ionomer-cement base, fracture was the predominant reason for failure, corresponding to 57.8% of total failures. Failure type distribution was different ($p = 0.007$) comparing restorations with and without base, but no effect in the overall survival of restorations was found ($p = 0.313$).

Significance. The presence of a glass-ionomer-cement base did not affect the survival of resin-composite restorations in the investigated sample. Acceptable annual failure rates after 18-years can be achieved with both techniques, leading to the perspective that an intermediate layer, placed during an interim treatment, may be maintained without clinical detriment, but no improvement in survival should be expected based on such measure.

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1. Introduction

The use of resin composites in posterior teeth was introduced about four decades ago [1], being currently a routine procedure in dentistry. The success of this material may be attributed to its adhesive properties, which allow reduced preparation sizes and minimally invasive or non-invasive restorative options, exceeding the possibilities of amalgam in the past [2]. Also, the use of composite resin can reinforce the remaining tooth structure, which is not possible with non-adhesive materials [3]. The esthetic appearance, limited cost involved and acceptable annual failure rates between 1 and 3% [4,5] are other advantages of resin composite restorations.

Nonetheless, methacrylate-based composites present inherent characteristics, such as polymerization shrinkage and stress [6], which may lead to tissue deflection and microleakage [7,8]. The deterioration of bonded interfaces resulting in clinically detectable marginal defects persists as a controversial issue regarding restoration success [9,10]. Thus, substantial effort in research is spent on materials and techniques to prevent clinical failures historically associated with marginal defects, viz. secondary caries [11].

To prevent marginal leakage and to compensate for the polymerization stress, an intermediate layer as base or lining underneath composite restorations may be used. Mostly glass ionomer-based or low-elastic-modulus resin-based materials have been used with this purpose. Several in vitro studies have shown that the application of such layer reduces microleakage and leads to an improved marginal quality [12-14]. Glass-ionomer materials would act on strain and marginal leakage reduction [15], presenting additional benefits as adhesion on dentin [16] and fluoride release [17], which may prevent secondary caries formation. On the other hand, from a clinical perspective, it has been suggested that the use cavity bases would have a weakening effect on the overall strength of the restoration, resulting in more fracture of composite restorations [4,18]. Nevertheless, few long-term clinical studies investigated this factor and divergent results were reported [18-20].

The aim of the present study was to investigate the influence of glass-ionomer cement base in the survival of posterior composite restorations up to 18 years. The hypothesis tested was that the use of glass-ionomer cement as intermediate material would have no effect in restoration survival, when compared to restorations without a base material.

2. Materials and methods

2.1. Study characteristics, participants and design

The database with clinical records of one dental office was used in the present evaluation. The survival of resin composite restorations in posterior teeth was determined retrospectively for up to 18 years, and the influence of several variables in the outcome was investigated. The absence or presence of an intermediate layer of glass-ionomer cement underneath composite restorations was the main factor under analysis, considering survival, annual failure rate and type of failure as outcomes. The other evaluated factors were age and gender of participants, jaw, restored tooth, number of restored surfaces and type of composite.

The study was approved by the local Ethics Committee (N. 139.840) and the patients have signed a written informed consent. Original data were obtained from a private dental office in Caxias, RS, Brazil, and a single operator (PARR) placed all restorations. The first dataset refers to restorations placed between 1986 and 1990, whereas the second dataset refers to restorations placed between 1994 and 2002. During the above mentioned periods, all new Class I and II direct restorations were searched, which could include from 1 up to 5 restored surfaces (information present in the patient files), with or without the involvement of cusps (not described in patient files). For inclusion, patients should present full dentition or the restoration should be in occlusion and with at least one adjacent tooth. Patients should have stayed in continuous clinical follow-up, with at least 1 annual recall. In total, 128 patients were selected through the inspection of clinical and radiographic records and invited to visit the dental office. The recruitment was performed by letters and phone calls, and 97 (76%) adult patients agreed to participate in the clinical evaluations. For the present study, the same patient could be part of both datasets.

2.2. Clinical procedures

The terminology may be somewhat confusing when addressing liners and bases [21]. For practical reasons, the term base will be used to describe the placement of intermediate layers covering most of the dentin part of the cavity. Also for practical reasons, the earlier dataset [22] will be referred as S1, and the later [23] as S2. In S1, restorations were placed using two composite resins, a minifilled hybrid composite with inorganic filler loading of 77 vol.% (P-50 APC; 3M ESPE, St. Paul, MN, USA), and a modified hybrid composite with inorganic filler loading of 57 vol.% (Herculite XR, Kerr, Orange, CA, USA). Bonding systems used were Scotchbond 2 (3M ESPE) for P-50 APC and XR Prime/XR Bond (Kerr) for Herculite XR. Restorations in S2 were performed using universal microhybrid composites (Z100, 3M ESPE; Tetric Ceram, Ivoclar-Vivadent, Amherst, NY, USA; Charisma, Heraeus Kulzer South America Ltda., São Paulo, SP, BR; or by the combination of these) with no substantial differences regarding filler loading (59, 60 and 56 vol.%, respectively). Bonding systems used were Scotchbond Multi-Purpose or Single Bond (3M ESPE). All restorations were placed under rubber dam isolation. Cavities were prepared using diamond burs, and low-speed steel burs were used to remove carious tissue. No bevels were made, and preparations were restricted to the removal of carious tissue and/or failed restorations. In deep cavities, including both S1 and S2 datasets, a thin layer of calcium hydroxide (Dycal, Dentsply Indústrias e Comércio Ltda., Petrópolis, RJ, BR) and conventional glass-ionomer cement (Ketac-Fil, 3M ESPE) were used to cover the deeper parts of the pulpal wall. In S1, the conventional glass-ionomer cement (GI; Ketac-Fil, 3M ESPE) was used as base in a closed sandwich technique, where the dentin was covered with GI, and the outline of the restoration was completely in composite resin. All other procedures were performed in the same way. The cavities

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were etched with 35% phosphoric acid, and bonding systems were applied according to the manufacturers’ instructions. The composites were placed incrementally, with layers of 2-mm under a horizontal technique, and cured for 40 s using a quartz–tungsten–halogen curing unit (Visilux, 3M ESPE). In class II cavities, contoured metal matrices and wooden wedges were used to restore the proximal boxes, each at a time in case both proximal surfaces were involved. Finishing procedures were performed with fine-grit diamonds and flexible rubber points/cups (FlexiPoints/FlexiCups, Cosmedent, Chicago, IL, USA) with aluminum oxide paste (Enamelize, Cosmedent). The proximal surfaces were finished by means of scalpel blades, abrasive finishing strips (3M ESPE), and finishing/polishing discs (Sof-Lex, 3M ESPE) for marginal ridges.

### 2.3. Evaluation of restorations

First, the history of the restorations was collected from the patient files. The date of placement and subsequent interventions were recorded. The restoration was considered as failed in case of replacement or repair, and the reason for failure was registered (as judged by the treating clinician). Also, a clinical evaluation was performed for all restorations still in function, by calibrated examiners according to FDI criteria [22,23]. The patients were examined at the dental office, and photographs were taken for future reference and documentation. The surfaces were air-dried and inspected with dental mirror and explorer, and the examiners were blinded to the materials. In case of disagreement, the examiners evaluated the restorations jointly, until a consensus was reached. For the analysis, different levels of each criterion were simplified according to re-treatment need: no intervention needed (success) and requiring intervention (failed).

### 2.4. Statistical analysis

Statistical analysis was performed using the software package Stata 11.0 (StataCorp LP, College Station, TX, USA). Fisher’s exact test was used to analyze the differences between materials and failure distribution and between techniques and type of failure distribution (α = 0.05). Kaplan–Meier method was used to generate survival curves up to 18 years, because follow-up periods were different in S1 and S2 datasets. A multivariate Cox regression analysis with shared frailty was used to investigate the influence of the variables of interest (technique, material, age, gender, jaw, tooth and number of restored surfaces) in restoration survival. The hazard ratios with respective 95% confidence intervals were determined. Only variables presenting p < 0.100 were selected for multivariate analysis.

### 3. Results

In total 632 posterior composite restorations placed in 97 patients were investigated. Eight patients were part of both datasets. Regarding gender, 64% of the patients were female and 36% male, with 412 and 220 restorations respectively. Concerning the use of an intermediate layer underneath composite restorations, in 57% (362) of the cases a glass-ionomer (GIC) base was placed (S1) and in 43% (270) no base material was placed (S2).

The distribution of the total number of restorations and failures are shown in Table 1 according to technique, dental arch and teeth. Regarding total number of failures, 30% (189) of the restorations have failed. Relative failures with GIC as base were 30% (110/362), while without an intermediate material 29% (79/270) of the restorations have failed. According to the number of restored surfaces, 22% (43) of total failures occurred in restorations with one surface, 33% (66) with two surfaces and 45% (90) with three or more surfaces.

Annual failure rate percentages (AFR) up to 18 years were 1.9%, for restorations with glass-ionomer cement base and 2.1% for restorations without intermediate material. The distribution of survival, cumulative survival and annual failure rate for each technique is shown in Table 2.

The distribution of the main reasons for failure according to technique is shown in Fig. 1. The frequency of failure due to secondary caries and fracture (restoration and tooth) was similar in the group with no lining, with 41.5% and 40.2% from total failures, respectively. In the group with glass-ionomer base fracture was the predominant reason for failure, corresponding to 57.8% of the total failures, while secondary caries represented 22.4% of the failures. The differences in type of failure distribution were statistically significant comparing techniques (Fisher’s exact test p = 0.007).

No statistically significant differences were seen between composite materials regarding survival (Fisher’s exact test, p = 0.201). Therefore composites were grouped under S1-composites (P-50 APC and Herculite XR), S2-composites (Z100, Tetric Ceram and Charisma) and Other (when more than one composite was used in the same restoration) in Cox-regression analysis, shown in Table 3. The investigated variables age (p = 0.357), gender (p = 0.227), jaw (p = 0.238), technique (p = 0.313) and resin composite (p = 0.179) did not affect the survival of restorations. Fig. 2 shows the Kaplan–Meier survival curves according to the technique used. Tooth and number of restored surfaces significantly affected survival.
Table 2 – Annual failure rate percentages for each technique up to 18- and 22 years of interval periods according to the cumulative survival retrieved from life tables.

<table>
<thead>
<tr>
<th>Time years</th>
<th>Number entering interval</th>
<th>Number of terminal events</th>
<th>Proportion surviving (%)</th>
<th>Cumulative proportion surviving at end of interval (%)</th>
<th>Annual failure rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC (S2)</td>
<td>5</td>
<td>281</td>
<td>36</td>
<td>87.2</td>
<td>87.2</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>244</td>
<td>36</td>
<td>85.0</td>
<td>74.1</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>201</td>
<td>9</td>
<td>94.1</td>
<td>69.7</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>94</td>
<td>1</td>
<td>97.9</td>
<td>68.3</td>
</tr>
<tr>
<td>RC + GIC base (S1)</td>
<td>5</td>
<td>350</td>
<td>17</td>
<td>95.1</td>
<td>95.1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>333</td>
<td>35</td>
<td>89.5</td>
<td>85.1</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>298</td>
<td>29</td>
<td>90.3</td>
<td>76.8</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>259</td>
<td>16</td>
<td>95.0</td>
<td>71.0</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>231</td>
<td>14</td>
<td>91.5</td>
<td>64.7</td>
</tr>
</tbody>
</table>

Fig. 1 – Representation of clinically acceptable restorations and failure type distribution according to each technique.

The Hazard Ratios of molar teeth was 2.57 compared with premolars, whereas restorations with three or more restored surfaces presented hazard ratios of 2.06 compared to single surface restorations. Kaplan–Meier survival curves according to tooth and number of restored surfaces are shown in Figs. 3 and 4.

4. Discussion

This study examined the influence of different restorative techniques on long-term survival of posterior composite restorations. Although the main factor under evaluation concerned the use of an intermediate layer, this variable was also related to the composite material used. Therefore, the present results and conclusions must take this fact into account.
Table 3 – Results of Cox regression analysis, with crude (*) and adjusted (c) hazard ratios (HR) for independent variables and failure of posterior restorations (97 patients; n = 632 restorations).

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>HRc (95% CI)</th>
<th>p</th>
<th>HRa (95% CI)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤30</td>
<td>1.00</td>
<td>0.357</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>≥31</td>
<td>1.24 (0.79–1.96)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.00</td>
<td>0.227</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Female</td>
<td>1.33 (0.83–2.11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jaw</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper</td>
<td>1.00</td>
<td>0.238</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Lower</td>
<td>1.18 (0.89–1.58)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technique</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RC</td>
<td>1.00</td>
<td>0.313</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>RC + GIC base</td>
<td>1.49 (0.68–3.28)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tooth type</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Premolar</td>
<td>1.00</td>
<td>&lt;0.001</td>
<td>1.00</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Molar</td>
<td>2.54 (1.85–3.49)</td>
<td></td>
<td>2.57 (1.86–3.53)</td>
<td></td>
</tr>
<tr>
<td>Number of surfaces</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One</td>
<td>1.00</td>
<td>0.002</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Two</td>
<td>1.12 (0.74–1.69)</td>
<td></td>
<td>1.33 (0.89–2.05)</td>
<td></td>
</tr>
<tr>
<td>Three or more</td>
<td>1.82 (1.22–2.72)</td>
<td></td>
<td>2.06 (1.38–3.08)</td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1-compositesb</td>
<td>1.00</td>
<td>0.179</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>S2-compositesd</td>
<td>0.80 (0.52–1.23)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Othere</td>
<td>1.29 (0.79–2.10)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b Herculite XR and P-50 APC.
d Z100, Tetric Ceram and Charisma.
e More than one of the listed composites used in the same restoration.

**Fig. 4 – Kaplan–Meier graph showing survival of restorations according to number of restored surfaces.**

Regarding the use of glass-ionomer cement (GIC) as base, annual failure rates (AFRs) found in this study (1.9%) were similar to that of restorations without a base material (2.1%) up to 18 years of follow-up. Although composites from each dataset were different, it could be pointed out that if the presence of a base would weaken the overall strength of the restoration, this would affect restoration survival, regardless of the composite used. The present results are in agreement with Lindberg et al. [19] and van Dijken [20] which have also found similar failure rates for restorations without base and with a compomer base.

On the other hand, the results reported by Opdam et al. [18] showed a lower survival when glass-ionomer bases were used in class II restorations, with AFRs of 3.8% for restorations with base and 1.4% without a base material. The differences between that and the present study could be partially related to the inclusion of one surface restorations in the present evaluation. Moreover, patient risk profiles, which were not assessed in the present study, could have played a role [18,23,24]. Among high caries risk patients, Opdam et al. [18] found similar AFRs for both techniques (2.8% with base and 2.7% without base), with 26% and 16% of failures due to secondary caries for restorations with and without base, respectively. Thus, it can be suggested that the fluoride release from the intermediate layer may not be effective in preventing secondary caries formation in high caries risk patients.

However, in the present study, more failures due to secondary caries were seen for composite restorations without base (41.5%) when compared to restorations with GIC base (22.4%). The reason for that is not clear and only speculations can be made from in vitro and in situ observations. Most of the fluoride release from GIC materials is reported to occur within a few years after constant exposure to water [25]. Yet, when used as a base, this exposure to the oral fluids would not take place, or, it would be very small within interfacial gaps formed after long-time functioning of the restoration and occlusal loading [26]. Since caries lesions can develop as wall lesions at the gap [27,28], the structurally bound and KOH-soluble fluoride in
dental tissues (adjacent to GIC) may promote reprecipitation of minerals preventing further demineralization [25] in the form of wall lesion. This alleged effect could play a role in low or moderate caries risk patients, where outer caries lesions are not developing.

Analyzing the frequency distribution of failures, a predominance of fracture (57.8%) was found for restorations with GIC base. In this sense, although the use of GIC base did not affect the overall survival, it was related to a higher occurrence of fracture, in agreement with the observations of Opdam et al. [18]. The fatigue of the intermediate layer could have contributed to these findings [29]. The mechanical properties of GIC are lower than those of composite and overtime the fatigue could produce deleterious effect on the base material. Indeed, an in vitro study has shown that under fatigue simulation, the flexural resistance of composite materials could be reduced in more than 40% when a base of GIC is present [30]. In this sense, further investigations should include the analysis in patients with bruxism and parafunctional habits, because the use of low-elastic-modulus bases might affect survival rates in a greater extent than in composite restorations without bases. This hypothesis is yet to be tested.

Additionally, the presence of a calciumhydroxide \((\text{Ca(OH)}_2)\) layer for indirect pulp protection may influence restoration survival [33]. In the present study, the cases in which \((\text{Ca(OH)}_2)\) was applied were only known for S2 dataset. In total, \((\text{Ca(OH)}_2)\) plus glass-ionomer cement was used in 45 restorations (out of 270) and the difference in distribution of failures between restorations with and without \((\text{Ca(OH)}_2)\) was not statistically significant (Fisher's exact test \(p = 0.477\); data not shown). Since there were a small number of cases in S2 and this information was missing in S1, these data was not included as a variable in the analysis. Future studies should also include this variable together with the remaining thickness of pulpal wall to investigate their influence in restoration survival.

The hypothesis of the present study was accepted as no significant differences on survival were found for restorations placed with or without GIC base at the investigated dental office. The other variables included in the analysis, and expressed in the Cox regression model, have confirmed previous findings. Restorations placed in molars were more prone to failure compared to premolars, probably due to the higher occlusal loading in the molars region, and the number of restored surfaces can also significantly affect the survival of restorations, mainly due to the less sound tooth structure left which could favor restoration breakdown [31–33]. Also, similar to other previous reports, the type of composite used did not play a significant role in the restoration survival after long periods of evaluation [33–35]. Such finding could be related to the fact that the composites used present good mechanical properties, and despite minor differences in composition, an adequate restoration survival is achieved. Finally, besides tooth and cavity variables, the survival of restorations with both techniques may depend on patient risk profiles and operator factors [35].

5. Conclusions

Under the limits of this retrospective evaluation, the use of glass-ionomer cement as base did not affect the survival of resin composite restorations. Acceptable annual failure rates of about 2% after 18 years can be achieved with both techniques, leading to the perspective that a glass-ionomer cement layer, placed during an interim treatment may be maintained without clinical detriment, but no improvement in survival should be expected based on such measure.

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