Efficacy of dentin-bonding agents in relation to application technique

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The gap-reducing efficacy of two dentin-bonding agents was examined in butt-joint dentin cavities prepared in extracted human teeth. The cavity wall and the surrounding dentin surface were treated with one of the dentin-bonding agents, and a light-activated microfilled restorative resin was either applied and polymerized or applied and then withdrawn from the cavity and once again applied before polymerization. Ten minutes after polymerization the width and the extent of the contraction gap were measured, using a light microscope, approximately 0.1 mm below the original free surface of the fillings. The marginal porosity was also registered and calculated in percentage of the total filling periphery. It was found that reapplication resulted in an increased marginal porosity and also that the width and extent of the contraction gap were increased when the restorative resin was reapplied. □ *Dental materials; in vitro study; marginal adaptation*

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The marginal adaptation of restorative resins is improved when these materials are applied with a syringe instead of a hand instrument; both the amount and the size of marginal voids are reduced when a syringe is used (1). But irrespective of the application instrument chosen, restorative resins should be handled as little as possible. The more these materials are manipulated, the higher the risk of porosity in the final restoration (2–5) and the higher the risk of catching air bubbles between the cavity wall and the restorative resin (1).

The purpose of this in vitro study was to examine to what extent application of a light-activated resin, followed by withdrawal of the material from the cavity and then reapplication would influence the efficacy of two different dentin-bonding agents; one of these is supposed to bond to the inorganic part and the other to the organic constituents of the dentin (6).

Materials and methods

The investigation was carried out on extracted human teeth of the permanent dentition. After extraction, the teeth were cleaned mechanically and stored in tap water at room temperature for from 1 to 28 days. One of the root surfaces was ground flat on wet no. 220 carborundum paper (Struers A/S, Denmark), and a cylindrical butt-joint cavity was prepared in the ground dentin surface; the cavity diameter was 4.0 mm and the cavity depth approximately 1.5 mm. The cavity and the surrounding dentin were treated with a dentin-bonding agent (either Gluma, Bayer, FRG, or Scotchbond Dual Cure, 3M, USA). The two adhesives were handled in accordance with the manufacturers' instructions.

Group A

A microfilled restorative resin (Silux, 3M) was applied with a syringe (Hawe-Neos, Switzerland), and the free surface of the filling was covered with a matrix (3M). The restorative resin was polymerized for 20 sec with a visible-light curing unit (Visilux, 3M) with close contact between the exit window of the lamp and the matrix. The matrix was then removed, and the tooth was placed in tap water. Ten minutes after polymerization, a standardized method of gentle wet-grinding and polishing was used to remove approximately 0.1 mm of the surface of the dentin and filling (7). The width of the maximum marginal contraction gap (MG) was then measured in a light microscope (Reichert MeF Universal Microscope, Vienna, Austria; 8 × 63) with a measuring ocular. Likewise, the extent of the gap (GP) was measured and calculated in percentage of the total filling periphery. Air bubbles that had destroyed 25 μm or more of the filling margin were also measured, and the marginal porosity was calculated in percentage of the filling periphery.

Table 1. Median values of the maximum marginal contraction gap in μm (MG) and of the extent of the gap in percentage of the total filling periphery (GP). Ranges are shown in parentheses next to each median

Group*	MG (μm)	GP (%)
A GL	2.3 (0–6.0)	30 (0–50)
SC	7.0 (4.0–10.0)	85 (71–100)
B GL	7.0 (0.6–8.0)	63 (25–81)
SC	10.0 (4.0–12.5)	88 (67–100)
S−	11.8 (10.0–15.0)	100 (88–100)

* GL = Gluma; SC = Scotchbond; S− = Silux without dentin-bonding agent.

Group B

The cavity and the surrounding dentin surface were treated with one of the two bonding agents. Silux was then applied to the cavity with the Hawe-Neos Syringe. Immediately after application the restorative resin was lifted out of the cavity with the tip of the syringe and thereafter placed in the cavity once again. The cavity was slightly overfilled and then covered with a matrix, whereafter the restorative resin was polymerized. The marginal contraction gap and the marginal voids were measured as described for Group A.

Base line

The contraction gaps of Silux were measured without previous use of a dentin-bonding agent and without re-application of the resin.

For each experimental condition 10 fillings were investigated. All procedures except cavity preparation and handling of the restorative resin and bonding agents were carried out in a room maintained at 36.5 ± 0.5°C.

Statistics

It has previously been found (8) that when dentin-bonding agents are used, there is a positive correlation between the maximum gap width (MG) and the extent of the gap in percentage of the total filling periphery (GP). The statistical analyses were therefore based on the formula (MG × GP)/100, referred to here as the marginal index (MI). The distributions of this index were skewed, and the analyses were therefore made with nonparametric statistics—that is, the Kruskal–Wallis one-way analysis of variance and the Mann–Whitney U test (9).

Results

Table 1 shows median values and ranges of the MG and the GP; this table elucidates the two variables included in the MI, which is shown in Fig. 1.

Group A

The two dentin-bonding agents could not prevent the formation of a contraction gap; Gluma had one filling without gap and Scotchbond Dual Cure had none. Gluma mediated an MI significantly smaller than that obtained with Scotchbond ($P < 0.001$). The median MIs were 0.7 (Gluma) and 5.5 (Scotchbond). With regard to the marginal porosity (Fig. 2), no statistically significant difference was found between 'Gluma fillings' and 'Scotchbond fillings' ($P > 0.05$). The median marginal porosity was 0.8% for Gluma and 0.6% for Scotchbond. Three of the 10 Gluma fillings and 4 of the 10 Scotchbond fillings had no marginal voids. It should be stressed that only voids ⩾ 25 μm were recorded.

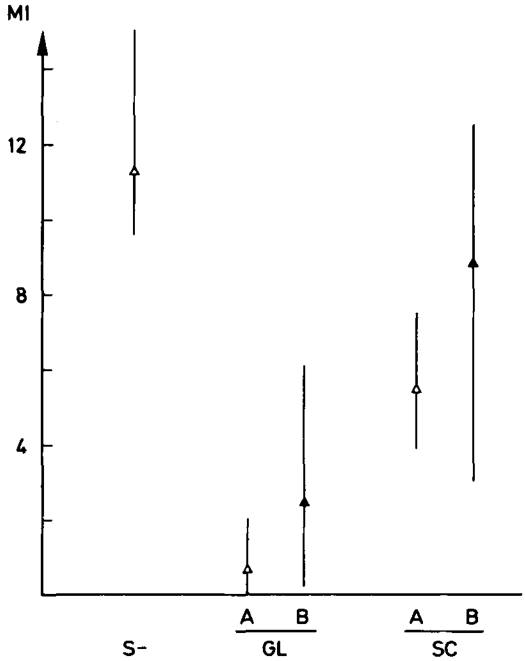

Fig. 1. Median marginal index (MI) for Silux without dentin-bonding agent (S−), for Silux in combination with Gluma (GL), or in combination with Scotchbond Dual Cure (SC). A = direct application; B = reapplication. Vertical bar = range.

Group B

The MI was markedly increased when the restorative resin was reapplied (Fig. 1, solid triangles). The difference between group A and group B was statistically significant for both dentin-bonding agents (Gluma, $P < 0.001$; Scotchbond, $P < 0.05$). The median marginal index was increased from 0.7 to 3.5 (Gluma) and from 5.5 to 8.8 (Scotchbond). The median marginal porosity (Fig. 2) was also significantly increased—from 0.8% to 6.4% for Gluma and from 0.6% to 4.3% for Scotchbond ($P < 0.01$ for both adhesives). Three Gluma fillings and three Scotchbond fillings had more than 10% marginal porosity. The average number of marginal voids ≥ 25 μm was 4.3 in group B and 2.0 in group A. Two fillings in group B had marginal voids ≥ 0.5 mm; the largest marginal void in group A was 0.25 mm.

Discussion

This study has shown that the gap-reducing efficacy of dentin-bonding agents may be markedly impaired if the restorative resin is reapplied. This may happen if the material, after having been applied to the cavity, sticks to the hand instrument or the tip of the syringe. The same problem may be found in case of an unstable matrix.

One of the reasons for the impaired marginal adaptation found after reapplication of the restorative resin (Fig. 1B) may be the increased marginal porosity (Fig. 2). For both dentin-bonding agents, the amount and the size of large marginal air bubbles were higher when the restorative material was reapplied. Marginal voids will reduce the adhesive area between bonding agent and resin. When the contact area between the adherents is diminished, fewer bonds are available to hinder the wall-to-wall shrinkage of the polymerizing resin. The result may be an impaired gap-reducing efficacy of dentin-bonding agents.

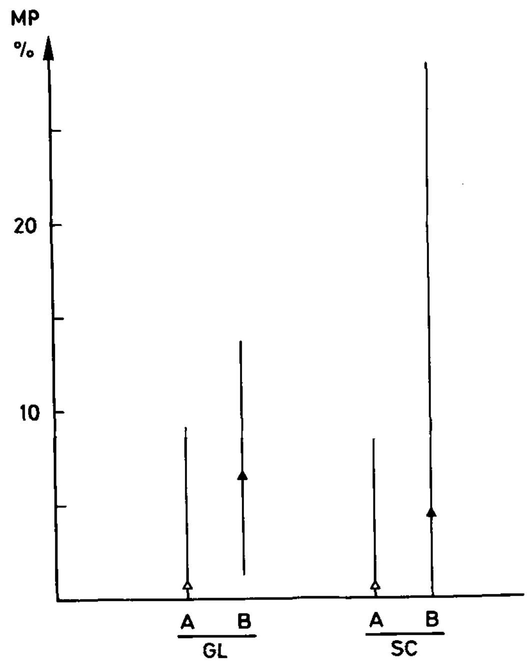

Fig. 2. Median marginal porosity (MP) with Gluma (GL) and with Scotchbond Dual Cure (SC) in relation to application procedure. A = direct application; B = reapplication. Vertical bar = range.

A further explanation may be related to the oxygen dissolved in the resin around these marginal air bubbles. It is well known that oxygen inhibits the polymerization of monomers because the reactivity of oxygen to the growing polymer is much higher than that of the monomer (10–12). This means that the competitive reactions of the free radicals with the monomers and with the dissolved oxygen will result in a reduced polymerization in all those areas where oxygen is available. The actual adhesive area between bonding agent and resin may thus be reduced, not only by the marginal voids but also by the oxygen-inhibited area around these air bubbles.

The present investigation confirms the general opinion that resin-based materials are sensitive to handling errors. Reapplication of restorative resins is still another problem that dentists should be aware of. Application of these materials must be done in such a manner that when contact between resin and bonding agent is established, this contact must not be broken.

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