Scientific Article

Adaptation of Class II Vitremer™ restorations with and without primer: a morphometric study

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Abstract

Purpose: *The aim of this study was to assess the adaptation of Vitremer with and without primer and compare to that of Z100™ with Scotchbond™ Multi-Purpose.*

Methods: *Fifty-seven Class II cavities were prepared in 32 extracted or exfoliated primary molars. The cavities were randomly assigned to one of three groups and restored as follows: group A, Vitremer with primer (20 preps); group B, Vitremer without primer (19 preps); and group C, Z100 with Scotchbond Multi-Purpose (18 preps). The restored teeth were thermocycled, embedded in acrylic resin, and sectioned. At least three 1-mm thick sections were obtained from each restoration. Adaptation of the materials was assessed by computerized quantitative morphometry using an image analysis system. In addition to the margin, the entire contact length between the tooth and the restorative material was measured. Voids were recorded separately for the base and cavity margins, and the percentage of defected length was calculated. At least three sections of each restoration were assessed. The section with the worst results was selected as the representative of the restoration.*

Results: *Margin defects were present in 14% of all the restorations, equally distributed between the three groups (A, 10%; B, 16%; C, 17%). A significant difference was found between groups B and C when the percentage of defects in the base was assessed.*

Conclusions: *Vitremer without primer presented considerably fewer voids when compared with Z100/Scotchbond Multi-Purpose. Although no difference in margin defects could be observed between the three groups a better adaptation to the cavity base was seen in the Vitremer restorations without primer. This finding might be of clinical importance and should be tested in other in-vitro and in-vivo studies. (Pediatr Dent 20:263–66, 1998)*

The concern expressed by practitioners and patients alike related to the use of amalgam led to a complete ban of its use in children in some European countries. Christensen[1] suggested other restorative concepts for primary molars: composite resin, conventional glass-ionomer cements (GICs), and resin-modified glass ionomers (RMGIs). Each of the materials presents advantages and disadvantages. Composites have good esthetics but are time consuming and it can be difficult to obtain a complete marginal seal.[2] GICs bond to enamel and dentin, require minimal or no cavity preparation, and release fluoride but are soluble and have low strength; therefore they cannot be recommended for use in major stress-bearing areas.[3] RMGIs have the fluoride-releasing properties and natural bond to the teeth of GICs, are less soluble with improved strength, and do not require protection from moisture contamination after initiation of the light-curing reaction as do GICs; however, they are less esthetic, rougher, and present more surface breakdown when compared to composites.[1,4] In RMGIs, the fundamental acid/base-curing reaction of GICs is supplemented by a second curing process initiated by light. Some of these materials, like Vitremer (3M Dental Products, St. Paul, MN) also have a third, late, chemical cure.[5] This tri-cure capability provides a significant advantage when the materials are light-polymerized, with a less-than-optimum output, when a greater thickness of material is used, or when some of the material lies in the shadow of tooth structures or metallic restorative materials.[6] The bonding mechanism of the RMGI is still not fully understood. There are possibly three factors involved in adhesion: 1) the glass ionomer penetrates through the smear layer into the dentinal tubules, providing micromechanical interlocking; 2) the material forms a polymer layer on the dentin surface; and 3) ions are exchanged between glass ionomer and dentin at their interface.[7] It has also been shown that a layer of polyacrylate ions enriched with phosphate and calcium ions diffused from tooth surface creates an adherent union with the hydroxyapatite crystals.[8] Randall and Hermsen[9] suggested that using an acidic primer on cavity walls will also etch or prime tooth surfaces outside the cavity margins. The primer, which is closely related to the cement liquid, modifies the smear layer and assures complete wetting of prepared internal tooth structure, causing a more intimate material/tooth interface.[10] When marginal gaps are present, the restoration could deteriorate more quickly if the material is poorly adapted to the cavity.

The aim of this study was to assess the adaptation of Vitremer with and without primer, and compare it to that of Z100 with Scotchbond Multi-Purpose (3M Dental Products).

Methods

The study material consisted of 32 human primary molars which were extracted or exfoliated naturally. The collected teeth were stored in water and were either intact, had a small carious lesion, or an old amalgam restoration that was removed during cavity preparation. Fifty-seven conventional Class II cavities were prepared using a #330 tungsten high-speed bur with coolant water spray, locating the cervical margins of the box in enamel. Twenty-five teeth had two cavity preparations, and the remaining seven had only one.

The preparations were randomly assigned to one of three groups (Table 1) and restored according to the following procedure.

Group A—Vitremer with primer:

1. Adapt a transparent celluloid matrix band (Howe-Neos Dental, CH-6925, Gentilino, Switzerland) with a Toffiemire matrix holder
2. Apply a primer to both enamel and dentinal surfaces for 30 s
3. Dry primer with air syringe and light cure for 20 s
4. Mix two scoops of powder and two drops of liquid within 45 s using a cement spatula
5. Inject the ionomer mix with a plastic syringe, in bulk, condense with a cotton-wool pledged dampened with water, and shape with a ball burnisher
6. Cure the restoration for 40 s through the occlusal surface and then for another 20 s from the buccal and lingual surfaces of the box
7. Remove the matrix band, trim, and polish
8. Apply a finishing gloss and light cure for 20 s.

Group B—Vitremer without primer: the restoration procedure followed the same steps as in Group A, except that primer was not used.

Group C—Z100/Scotchbond Multi-Purpose (Control):

1. (Similar to group A)
2. Apply a phosphoric acid etchant for 15 s
3. Rinse, apply primer, and air dry
4. Apply a bonding agent and cure for 10 s
5. Place one buccal and one lingual increment of Z100 at the approximal box leaving room for a third middle increment, as described by Holan et al.[11]
6. Expose each of the increments to a light source directed buccally or lingually for 20 s
7. Place the third increment, fill the cavity up to the level of the pulpal floor, and light polymerize for 20 s
8. Fill the rest of the cavity and light polymerize for another 20 s
9. Remove the matrix, and finish the restorations with alpine stones.

All restorations were polished with a set of Soflex™ aluminum oxide discs (3M Dental Products) to decrease roughness.

The restored teeth were kept at room temperature and 100% humidity for 2 weeks to prevent dehydration. They were then thermocycled for 500 cycles between 4°C ± 2° and 60°C ± 2° with dwell time of 1 min in each bath and 1-min intervals between the baths in ambient atmosphere. Remnants of roots were removed and the pulp chambers were sealed with Intermediate restorative material (IRM, Bayer, Leverkussen, Germany).

The teeth were placed in plastic rings and embedded in self-curing acrylic. They were then sectioned on a vertical plane parallel to the mesiodistal axis of the tooth using the Isomet low-speed saw (Buehler Ltd., Lake Bluff, IL). Each section was 1 mm thick, thus allowing evaluation of at least three sections of each restoration.

Computerized quantitative morphometry

Adaptation of the material was assessed by computerized morphometry using a CUE-3 image analysis system (Galai Ltd., Migdal Haemek, Israel). The software, designed as a joint venture between Olympus and

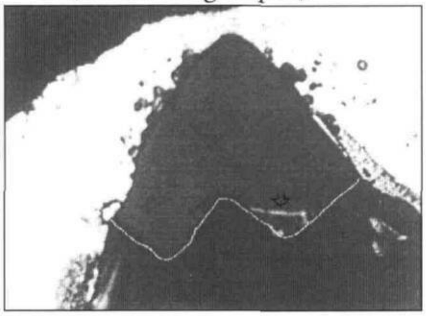

Fig 1. Photograph showing computerized morphometric tracing of the cavity base. Dotted line represents the measurement of the cavity base length. Notice the gap at the gingival floor of the restoration (arrow).

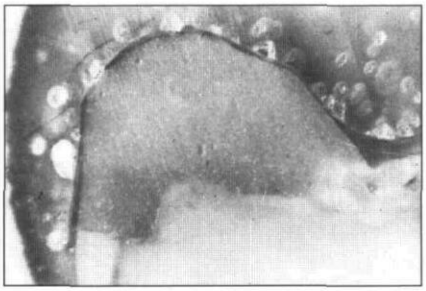

Fig 2. Vitremer restoration of group B (without primer) showing good adaptation, as no gap is evident.

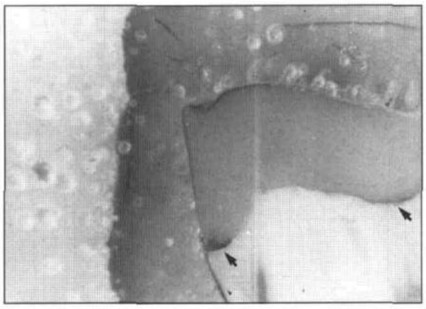

Fig 3. Restoration with Z100 and Scotchbond Multipurpose (group C). Notice gaps at the gingival margin of the box and in part of the gingival floor of the occlusal lock (arrows).

TABLE 1. MEAN ABSOLUTE LENGTH (IN MM) OF CAVITY BASE

Group	Type of Restoration	N*	Mean (SD)
A	Vitremer with primer	20	0.66 (1.33)
B	Vitremer without primer	19	0.13 (0.25)
C	Z100/Scotchbond Multipurpose	18	0.56 (0.55)

*Number of preparations.

TABLE 2. MEAN ABSOLUTE LENGTH (IN MM) OF CAVITY MARGINS

Group	Type of Restoration	N*	Mean (SD)
A	Vitremer with primer	20	0.08 (0.25)
B	Vitremer without primer	19	0.07 (0.19)
C	Z100/Scotchbond Multipurpose	18	0.14 (0.35)

*Number of preparations.

TABLE 3. PERCENTAGE OF VOIDS IN THE CAVITY BASE

Group	Type of Restoration	N* (%)	Standard Error
A	Vitremer with primer	20 (60%)	11.2
B	Vitremer without primer	19 (26%)	10.3
C	Z100/Scotchbond Multipurpose	18 (61%)	11.8

*Number of preparations.

TABLE 4. PERCENTAGE OF VOIDS IN THE CAVITY MARGINS

Group	Type of Restoration	N* (%)	Standard Error
A	Vitremer with primer	20 (10%)	6.9
B	Vitremer without primer	19 (16%)	8.5
C	Z100/Scotchbond Multipurpose	18 (17%)	8.9

*Number of preparations.

Galai, allows measurement of different morphological features consisting of length, area, perimeter, aspect, ratio, shape factor, etc., directly from histological slides. The CUE-3 system comprises a high-resolution CCD camera (M-852, Sony, Japan) for image acquisition; a motorized positioning and autofocusing system, including remote control and automatic movement of the specimen holder table; a digitizing card installed in a PC-AT-type computer; a monitor on which the acquired pictures can be continuously displayed; and a software package that enables image freezing, editing, processing, segmentation, and thresholding into objects on background for analysis of shapes and color shades.

The entire contact length between the tooth and the restorative material was measured. Voids were recorded separately for the base and cavity margins, and the percentage of defected length was calculated (Fig 1). At least three sections were assessed for each restoration. The section with the worst results was selected as the representative of the restoration. ANOVA and Scheffe's procedures were used to analyze the differences between the groups.

Results

The mean absolute length of the bases and margins of the restorations is presented in Tables 1 and 2. Mean total defected length was 0.55 mm with no significant differences between the groups. Forty-nine percent of the restorations presented with voids in their bases, and their distribution in the groups is shown in Table 3. Of these, 61% were restored with Z100, 60% with Vitremer with primer, and 26% with Vitremer without primer. These differences were not, however, statistically significant ($P = 0.0513$). Margin defects were present in 14% of all the restorations, equally distributed between the three groups, as shown in Table 4. A significant difference was found between groups B and C when the proportion of defects in the base was assessed. Vitremer without primer presented considerably fewer voids when compared with Z100 and Scotchbond Multi-Purpose (Scheffe test $P = 0.0328$). Representative sections of the restorations are presented in Figs 2 and 3. In Fig 2, good adaptation is evident, both at the cavity base and margin, in a Vitremer restoration without primer. In Fig 3, gaps can be observed at the gingival floor and in part of the occlusal lock (arrows) of a Z100 and Scotchbond Multi-Purpose restoration.

Discussion

The mechanism of adhesion of RMGI to tooth structure is not completely clear and is still being investigated.[5] Secondary ion mass spectrometry studies have confirmed that an ionic exchange process takes place between an RMGI and the dentin surface, with evidence of movement of ions from the cement into the dentin and vice versa.[12] The adhesion of RMGI appears to be via the development of an ion exchange layer adjacent to the dentin similar to conventional GICs.[5]

"Conditioning" the tooth surface with a weak acid has been advocated to enhance the bond strength of conventional GIC.[13, 14] Another view has been held concerning RMGI, i.e., that it is adhesive and requires no surface conditioning of the tooth structure due to the HEMA content.[15] This might be the reason for the presence of fewer voids in the group without primer. Nevertheless, the bond strength of commercial restorative material appears to be higher to conditioner-treated dentin than it is to untreated dentin.[16] A good marginal adaptation was observed in restorations with and without primer in this study, and no statistical difference was seen between the groups. However, fewer marginal defects (10%) were seen in the group conditioned with primer.

The microleakage performance for any restorative material is critical. Marginal leakage can occur because of dimensional changes and/or lack of adaptation of the restoration to the cavity walls. Considerable percolation at the margins could occur if there is a significant mismatch between the material and tooth substance. This would result in transitory or permanent gap formation, leading to fluid and molecular movement with undesirable sequelae.[5]

Microleakage of restorations has been commonly studied by assessing the penetration of dyes through the cavity margins.[17–20] Although this method is simple and inexpensive, it is not always accurate, as sometimes the dye can penetrate through a crack on the enamel close to but outside the margin of the restoration. Moreover, a restoration with penetration of dye through the dentin into the pulp reflects the permeability of dentin, not the poor adaptation of the restoration.[17, 18]

Assessing adaptation of restoration using computerized micromorphology is actually a breakthrough in in-vitro studies, as it is possible to measure the gaps and have an objective and exact value. In our study, voids resulting from incomplete contact from the material with the cavity base could be disclosed in some restorations without gaps in the margins. This finding has not been described previously. Voids in the base might have been present in other restorations, but might not have been disclosed, as dye had to penetrate through the margins. Two questions arise from this observation: could this finding also be disclosed clinically, and if so, what would its long-term significance be? It would be interesting to examine exfoliated restored primary teeth and assess the materials after a period of clinical use to see if these gaps are present.

The ultimate success of a material is indicated by its longevity in the oral cavity. As the initial in-vitro trials do not always reveal full limitations, clinical data are essential. Although not many clinical studies offering life expectancy data on RMGIs are available, preliminary results are promising.[21, 22]

The idea of comparing Vitremer with and without primer was to establish whether it would function similarly in primary molars. Using Vitremer without the priming step could make it easier and faster to place, an asset in pediatric dentistry where many times a fast technique is desired due to the short attention span of some children. The results of the present study demonstrated a better adaptation of Vitremer to the cavity base without primer, encouraging clinical testing of this hypothesis. However, this idea should be tested in vitro first, with placements made in high humidity conditions to simulate the oral cavity, before any clinical evaluation could be conducted.

Dr. Gleicher is clinical instructor and Professor Fuks is a professor in the Department of Pediatric Dentistry and Dr. Sela is professor and Head of the Department of Oral Pathology, all of Hebrew University, Hadassah Faculty of Dental Medicine, Jerusalem, Israel.

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