DENTAL MATERIALS 23 (2007) 279–287

available at www.sciencedirect.com

journal homepage: www.intl.elsevierhealth.com/journals/dema

Marginal adaptation and microtensile bond strength of composite indirect restorations bonded to dentin treated with adhesive and low-viscosity composite

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ARTICLE INFO

Article history:
Received 31 March 2005
Received in revised form
29 November 2005
Accepted 10 January 2006

Keywords:
Composite resin
Adhesive resin
Resin cement
Marginal adaptation
Bond strength

ABSTRACT

Objectives. This study evaluated the marginal adaptation of composite indirect restorations bonded with dual curing resin cement after different strategies to seal dentin. Different bonding techniques associated or not with a low-viscosity composite resin (LVCR) were utilized. In addition, the bond strength between composite resin and pre-sealed dentin was evaluated in the buccal and pulpal walls of class I cavities, prepared for indirect restorations.
Methods. Thirty-three freshly extracted human molars were used for this study, divided into three groups ($n = 11$) representing different techniques to seal dentin—(Group 1) Conventional technique: the adhesive system was applied and polymerized just before the cementation of the indirect restoration; (Group 2) Dual bonding technique: a first layer of the adhesive system was applied and polymerized just after preparation, and a second layer just before the final cementation; (Group 3) Resin coating technique: a LVCR was applied and polymerized after the first layer of the adhesive system, and before the impression. A further application of the adhesive system was performed before the placement of the restoration. The restorations were polished and a solution of acid red propylene–glycol was dropped on each specimen's occlusal surface for 10 s. The dye penetrations were captured under stereoscopic lens and the images were transferred to a computer with a measurement program, in order to determine the extension of the dye penetration. The microtensile bond strength test (μTBS) was applied on pulpal (P) and buccal (B) walls of the restorations for Groups 1–3. The subgroups for μTBS were: Group 1P ($n = 13$); Group 1B ($n = 7$); Group 2P ($n = 6$); Group 2B ($n = 14$); Group 3P ($n = 14$); Group 3B ($n = 15$). All specimens were sectioned to obtain an area of 0.8 mm^2. The specimens were mounted on a microtensile device and fractured using a universal testing machine at a cross-head speed of 1 mm/min. Failure modes were analyzed by SEM. One-way ANOVA and multiple-comparison Tukey's test were used for statistical analysis of the marginal adaptation scores and μTBS test. Non-parametrical Kruskal–Wallis test was used for failure mode analysis.
Results. Group 3 showed a significantly higher mean value of marginal dye penetration (45.59) when compared to Groups 1 (8.44) and 2 (18.92). For pulpal walls, Group 1P showed significantly higher mean μTBS (25.93 ± 2.27) when compared to Groups 2P (14.71 ± 1.78) and 3P (16.07 ± 2.81). There was no statistical difference between Groups 2P and 3P. For buccal walls,

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doi:10.1016/j.dental.2006.01.028

Group 2B presented significantly higher mean μTBS (23.29 ± 1.42), and Group 1B the lowest mean values (11.37 ± 1.14). The failure mode analysis presented a considerable variation, according to the treatment and to the wall. The results of this study indicated that a previous sealing of dentin using the adhesive system, followed by a second application just before the cementation, is an effective alternative technique, since it maintains the marginal adaptation of indirect composite resin restorations, and improves the bond strength at the interface on buccal walls, which are the most critical regions for the long-term durability of these procedures.

1. Introduction

The modern concepts of direct or indirect restorative dentistry have tried to acquire in esthetic restorative materials, techniques to recover biomechanically teeth that have lost part of their structure due to caries or trauma. Composite resin has been the material of choice for this function, based on the similarity of its elastic modulus with the dental structures, and due to its high potential to bond to enamel and dentin [1].

These characteristics of composite resin, when associated with adhesive systems, have created technical alternatives that have increased the utilization of esthetic restorations. The improvements in inorganic filler (amount, type and average size), and the molecular weight of monomers that compose the organic phase, have made modern composite resins easier to manipulate and apply. However, these materials still present problems related to marginal integrity and leakage, mostly due to their inherent polymerization shrinkage [2–5].

Generally, composite resins are applied by the direct technique, in placement of restorations in anterior and posterior teeth. In the polymerization process, the chemical reaction that occurs in the organic phase of the composite produces the conversion of monomers into polymers, resulting in a molecular forthcoming with the consequent shrinkage [1]. The extent of this shrinkage influences the tension state generated at the interface composite/dental structure and, commonly, compromises the bond integrity at this region. In addition, the polymerization shrinkage of composites is also influenced by the geometric form of the cavity. When the ratio between the bounded to unbounded surfaces is higher than two, the stress generated by the composite shrinkage may exceed the bond strength to the cavity walls and produce marginal gaps [6]. When these problems are added to an incorrect placement technique and finishing mistakes, marginal leakage, inadequate anatomic form and proximal contacts occur clinically, which lead to a consequent reduction in the longevity of the restoration [7,8].

At the beginning of the 1990s, indirect composite restorations were shown to present improved clinical conditions with respect to proximal contact, occlusal anatomy and marginal adaptation [9,10]. In these cases, all technical procedures of manufacturing and polymerizing of the restorations were performed externally and just a thin layer of a high flow composite resin (so-called resin cement) was used to lute the restorations [11]. It is important to highlight, however, that during the polymerization of the resin cements, tensions could arise, causing a disruption between the restoration and the cavity walls, leading to marginal leakage, mainly if the margins are located in dentin [12–17]. Thus, marginal integrity is directly related to the bond strength between the dentin surface and the adhesive system/resin cement indicated for luting indirect restorations [18,19].

Tooth preparation for indirect restorations can induce significant dentin exposures and, consequently, sensitivity. The conventional technique for indirect restorations consists in molding the cavity immediately after preparation and protecting temporarily the teeth for the patient's functional and esthetic needs. Then, after the fabrication of the indirect restoration, the provisional cement is removed and the adhesive/luting procedures are performed. It is important to emphasize that freshly cut dentin has been demonstrated to be the ideal substrate for bonding, therefore, dentin contamination due to provisional cements could reduce the potential for dentin bonding, leading to lower bond strengths, failure in the hybridization process and post-operative sensitivity [20–22]. Alternative techniques have been suggested to overcome these problems; it has been reported that it is possible to considerably augment bond strength values when the dentin surface is sealed with an adhesive system, prior to molding procedures and before the application of temporary materials, and when a new layer of adhesive is applied at the moment of the final luting of the restoration, the so-called "dual bonding" or "immediate dentin sealing" technique [20,21,23]. The reasons supporting this technique are the increase in bond strength over time, since dentin bond can develop without stress, resulting in improved adaptation [24,25], and the protection of dentin against bacterial leakage and sensitivity during provisionalization and after final luting [26].

The application of a LVCR on the adhesive layer has also been suggested immediately after cavity preparation [27]. This technical procedure seems to reduce gap formation at the interface dentin/resin cement [28,29], and improve bond strength. Moreover, it could serve as a resilient layer between the restorative composite resin and dentin, absorbing the tensions generated by the polymerization shrinkage of the resin cement and mastication efforts [5,25,30].

Thus, the aim of the present investigation was to evaluate the marginal adaptation of indirect composite resin restorations luted with resin cement, after sealing dentin with an adhesive system associated, or not, with LVCR. Additionally, the study aimed to evaluate the bond strength between composite resin and pre-sealed dentin, in buccal and pulpal walls of Class I cavities, configured for indirect restorations.