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Effect of immediate and delayed dentin sealing on the fracture strength, failure type and Weibull characteristics of lithiumdisilicate laminate veneers

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ABSTRACT

Objectives. Adhesion on dentin is less reliable than on enamel, which could affect the durability of laminate veneers (LV). Immediate dentin sealing (IDS) is suggested instead of delayed dentin sealing (DDS) to overcome hypersensitivity and prevent debonding from dentin. This study evaluated the effect of IDS and DDS on the durability of $\text{Li}_2\text{Si}_2\text{O}_5$ laminate veneers in vitro.

Methods. Window preparations were made on the labial surfaces of sound maxillary central incisors ($N=50$). They were randomly divided into five groups: Group 1: Enamel only + H_3PO_4 + Adhesive (control); Group 2: $<1/4$ dentin + H_3PO_4 + DDS (2 weeks later); Group 3: Complete dentin + H_3PO_4 + DDS (2 weeks later); Group 4: $<1/4$ dentin + H_3PO_4 + IDS; Group 5: Complete dentin + H_3PO_4 + IDS. $\text{Li}_2\text{Si}_2\text{O}_5$ laminate veneers (e.max Press) were bonded to the labial surfaces of the teeth with adhesive resin cement (Variolink Veneer). IDS layers were silicacoated (CoJet System) and silanized (ESPE-Sil). The teeth with their bonded laminates were thermocycled ($10,000\times$ cycles) and then subjected to static loading (1 mm/min). Failure type and location after debonding were classified. Data were analyzed using ANOVA and Tukey's post hoc test ($\alpha=0.05$). Two-parameter Weibull distribution values including the Weibull modulus, scale (m) and shape (ϕ), values were calculated.

Results. Mean fracture strength (N) per group in descending order was as follows: Group 5 (576 ± 254), Group 4 (478 ± 216), Group 1 (473 ± 159), Group 2 (465 ± 186), and Group 3 (314 ± 137). The presence of complete dentin exposure sealed with DDS after 2 weeks on the bonded surface (Group 3) resulted in significantly lower fracture strength results than those in group 5 with IDS ($p=0.034$). Weibull distribution presented higher shape (ϕ) for Group 1 (3.67), than those of other groups (2.51–2.89). Failure types were predominantly adhesive failure between the cement and the laminate veneer in Groups 1, 2, 4 whereas Group 3

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presented more often complete adhesive failures between the cement and dentin. In Group 5, failures showed some IDS and cement with or without ceramic fracture attached on the tooth.

Significance. When laminate veneers are bonded to a large dentin substrate, application of immediate dentin sealing improves adhesion and thereby, the fracture strength of $\text{Li}_2\text{Si}_2\text{O}_5$ laminate veneers.

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1. Introduction

Laminate veneers in particular entail minimal tooth preparation of only 0.3–0.9 mm, which is highly conservative when compared to their full-coverage crown alternative. Although preparation for laminate veneers could be achieved within the vicinity of enamel, some dentin exposure, especially at the cement–enamel junction or below in the cervical area, is sometimes unavoidable [1–3]. Freehand preparation of such restorations, without the use of putty indices or guiding grooves of depth may yield to deeper preparations with higher amount of dentin exposure [2]. Preparation depth may in fact have consequences on the final fracture strength of minimal invasive restorations, in that lower fracture strength results were reported for laminate veneers when bonded to dentin compared to enamel [4]. Unfortunately, clinical studies on survival of laminate veneers do not often report whether preparations were solely in enamel or dentin. Yet, available evidence from clinical studies that reported dentin exposure after tooth preparation, also reported higher incidence of failures [5–8]. Recently, a review on the clinical evaluation of laminate veneers bonded to dentin concluded that the survival rate diminished when such restorations were bonded to dentin [9].

In order to prevent micro-leakage and hypersensitivity, sealing of the dentin prior to impression taking for the indirect restorations was advocated in early 1990s [10]. In addition, other studies concluded that adhesive strength of restorations was improved when dentin was sealed [11–15]. Adhesive strength after this so called immediate dentin sealing (IDS) was compared with the conventional adhesive cementation, delayed dentin sealing (DDS), which is a common procedure for cementation of fixed dental prosthesis. In these studies, bond strength results employing DDS varied between 2 and 12 MPa, whereas application of IDS resulted in significantly higher mean bond strength results between 15 and 58 MPa depending on the test method [12,14–16]. Apparently, application of the adhesive resin on freshly cut dentin and further polymerization of the adhesive resin over time improved adhesion of bonded restorative materials [17,18]. Furthermore, it was also postulated that application of IDS results in a smooth surface that also improves the adaptation of the indirect restorations [19].

Clinical studies on the survival rate of laminate veneers bonded onto teeth with existing resin composite restorations did not show encouraging results, providing that the substrate surfaces were not conditioned [6–8]. However, in an *in vitro* study, ceramic laminate veneers bonded to a complete

composite surface presented higher fracture strength results than those bonded onto enamel [20]. Similarly, clinical survival rate of laminate veneers bonded onto teeth with existing composite restorations after the latter was tribochemical silicacoated, was not less than those bonded on enamel/dentin up to 40 months of evaluation [21]. Thus, it can be anticipated that the presence of adhesive resin would also not impair the bond strength of laminate veneers on the IDS.

The objectives of this study therefore were to (a) compare the fracture strength of laminate veneers with and without IDS application, (b) evaluate the influence of the size of the exposed dentin and (c) failure types after loading until fracture. The first hypothesis tested was that the presence of IDS would positively contribute to the fracture strength of the laminate veneer compared to conventional adhesive cementation (DDS). The second hypothesis tested was that the size of exposed dentin would not decrease the fracture strength of the laminate veneers.

2. Material and methods

2.1. Specimen preparation

The brands, types, main chemical compositions, manufacturers and batch numbers of the materials used for the experiments are listed in Table 1. Schematic description of the experimental design is presented in Fig. 1.

Sound human central incisors ($N=50$) of similar size, free of restorations and root canal treatment were selected from a pool of recently extracted teeth. All teeth were screened on the presence of cracks by blue light and those with cracks were eliminated and replaced with new teeth. Before a laminate veneer preparation was made, impressions were made using a high precision condensation silicone (Provil Novo putty fast set, Heraeus, Hanau, Germany) in order to obtain molds for the provisionals. Window type of tooth preparations without incisal overlap, were made with a depth-cutting bur (801 201SC Swiss Dental Products, Intensiv Grancia, Switzerland), with this preparation type adhesion of the laminate did not rely on the macro-mechanical retention as in the case of overlap preparations. After the depth cuts of 0.3 mm were made, preparation was finalized using a round-ended tapered diamond chamfer bur (Swiss Dental Products, FG-2309). The preparations ended 1 mm above the cement–enamel junction.

The amount of dentin exposure was controlled by etching the prepared surface for 5 s and rinsing with water that resulted in a white, dull enamel surface. Thereafter photos of

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