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Curing mode affects bond strength of adhesively luted composite CAD/CAM restorations to dentin

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ABSTRACT

Objectives. To determine the effect of curing mode and restoration-surface pre-treatment on the micro-tensile bond strength (μ TBS) to dentin.

Methods. Sandblasted CAD/CAM composite blocks (LAVA Ultimate, 3M ESPE) were cemented to bur-cut dentin using either the etch & rinse composite cement Nexus 3 ('NX3', Kerr) with Optibond XTR ('XTR', Kerr), or the self-etch composite cement RelyX Ultimate ('RXU', 3M ESPE) with Scotchbond Universal ('SBU', 3M ESPE). All experimental groups included different 'curing modes' (light-curing of adhesive and cement ('LL'), light-curing of adhesive and auto-cure of cement ('LA'), co-cure of adhesive through light-curing of cement ('AL'), or complete auto-cure ('AA')) and different 'restoration-surface pre-treatments' of the composite block (NX3: either a silane primer (Kerr), or the XTR adhesive; RXU: either silane primer (RelyX Ceramic Primer, 3M ESPE) and SBU, or solely SBU). After water-storage (7 days, 37 °C), the μ TBS was measured. Additionally, the degree of conversion (DC) of both cements was measured after 10 min and after 1 week, either auto-cured (21 °C/37 °C) or light-cured (directly/through 3-mm CAD/CAM composite).

Results. The linear mixed-effects model ($\alpha=0.05$) revealed a significant influence of the factors 'curing mode' and 'composite cement', and a less significant effect of the factor 'restoration-surface pre-treatment'. Light-curing 'LL' revealed the highest μ TBS, which decreased significantly for all other curing modes. For curing modes 'AA' and 'AL', the lowest μ TBS and a high percentage of pre-testing failures were reported. Overall, DC increased with light-curing and incubation time.

Significance. The curing mode is decisive for the bonding effectiveness of adhesively luted composite CAD/CAM restorations to dentin.

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1. Introduction

Due to the patient's demand for esthetic restorations and minimal-invasive treatment modes, tooth-colored restorative materials are today preferred. Dental composite is used to restore anterior and posterior teeth. Besides applied 'directly', composite is also indicated for indirect restorations, in particular for medium-to-large sized cavities on the condition that sufficient tooth structure remains for adhesive cementation [1]. Especially with larger Class-II restorations, different clinical parameters such as marginal adaption, proximal contacts, anatomic form, color match, polymerization shrinkage and wear resistance can then clinically be easier controlled [1,2]. With the introduction of CAD/CAM techniques [3], posterior restorations can be prepared chairside within only one single appointment. Apart from various ceramic materials [4–6], indirect composite restorations can also be milled from preformed composite blocks, such as Paradigm MZ 100 (3M ESPE, Seefeld, Germany) [4]. This CAD/CAM composite block is based on small-particle hybrid composite technology (Z100, 3M ESPE); it was documented to reveal a 10-year survival rate of 79.4% [3]. Recently, this block was replaced by Lava Ultimate (3M ESPE), containing a filler mixture of silica (20 nm) and zirconia nanomers (4–11 nm) with a total filler load of approximately 80 wt% (Lava™ Ultimate CAD/CAM Restorative, Technical Product Profile, 3M ESPE, 2011).

Regarding restoration-surface pre-treatment to adhesively lute indirect composite (and ceramic) restorations, a new so-called 'universal' adhesive (Scotchbond Universal, 3M ESPE) with an in-built silane was introduced. Separate application of a silane primer is claimed to be no longer needed, while in literature various restoration-surface pre-treatments are generally recommended, such as sandblasting with aluminiumoxide (27–50 µm), silane coupling, (solely) application of a bonding agent, tribochemical silica sandblasting (Cojet, 3M ESPE), hydrofluoric acid etching, etc. [6–8].

Apart from surface pre-treatment, other factors that may affect the adhesive cementation of indirect (composite) restorations are the kind of composite cement as well as the curing mode of both adhesive and composite cement. So-called 'self-adhesive' (and NOT 'self-etch', as they hardly etch) composite cements that do not require a separate tooth pre-treatment generally underperform multi-step composite cements in terms of bond strength [9,10]. In addition, auto-curing of composite cements mostly also results in lower bond strength than when the cement is light-cured [11–13]. For instance, restorations of 3 mm and thicker lead to a decreased degree of conversion (DC) of the luting composite [14]. Also the environmental temperature has an effect on DC: a higher DC and faster polymerization rate are achieved with a higher temperature [15]. The same effect was recorded for dual-cure composite cements when both light- and self-cured [16].

In this study, we aimed to determine the effect of 'curing mode' and 'restoration-surface pre-treatment' of CAD/CAM composite blocks luted with two 'composite cements' (on the bond strength to dentin 3 experimental variables). The first hypothesis tested was that the micro-tensile bond strength (μ TBS) of CAD/CAM composite to bur-cut dentin is neither

influenced by the 'composite cement' (1a), the 'restoration-surface pre-treatment' (1b), nor the 'curing mode' (1c). In addition, we measured DC of the two composite cements when cured following different curing modes at different temperatures. The second hypothesis tested was that there is no difference in DC for the two composite cements tested (2a), and that DC is neither influenced by the 'curing mode' (2b), nor the 'curing conditions' (2c).

2. Materials & methods

2.1. Preparation of dentin surfaces

Dentin surfaces of 48 human third molars were prepared as described by De Munck et al. [17] and randomly assigned to one of 12 experimental groups. Before cementation, the dentin surfaces were roughened using a medium-grit (100 µm) diamond bur (842; Gebr. Brasseler, Lemgo, Germany), fixed in a water-cooled high-speed turbine mounted into a custom-modified Micro-Specimen Former (University of Iowa, Iowa City, IA, USA) in order to produce a uniform and clinically relevant 'bur-cut' smear layer. The teeth were warmed up in an incubator to 37 °C for 15 min, after which the blocks were immediately cemented and the specimens were again transferred into the incubator prior to further specimen processing. For adhesive cementation, 2 different self-etch composite cements were used: Nexus 3 in combination with Optibond XTR ('NX3' and 'XTR'; both Kerr, Orange, USA) and RelyX Ultimate with Scotchbond Universal ('RXU' and 'SBU'; both 3M ESPE).

2.2. Pre-treatment of CAD/CAM composite

The CAD/CAM composite blocks (LAVA Ultimate CAD/CAM blocks for CEREC, 3M ESPE) were sectioned into 3 smaller blocks (thickness of 3 mm) using a semi-automatic high-precision diamond saw (Accutom 50, Struers, Ballerup, Denmark). Afterwards, their surfaces were divided into 2 parts by cutting a shallow, approximately 1-mm deep groove in the middle with a water-cooled diamond saw (Isomet low speed diamond saw, Buehler, Lake Bluff, IL, USA). The whole surface was then sandblasted with aluminiumoxide (50 µm; Rönvig Dental Mfg. A/S, Dagaard, Denmark) for 5 s and cleaned with ethanol. A razorblade was inserted into the groove in order to separate the two block halves from each other and to enable two different restoration-surface pre-treatments per block. Four different restoration-surface pre-treatment modes were used: for 'NX3', either a resin-containing silane primer ('SP', Kerr Silane Primer) or the adhesive of Optibond XTR ('XTR Ad'; Kerr); for 'RXU', either a silane primer ('CP', RelyX Ceramic Primer, 3M ESPE) and Scotchbond Universal ('SBU', 3M ESPE) or solely the adhesive SBU. Independently of the 4 curing modes applied (see below), the adhesive applied on the composite block was only air-thinned, but not cured.

2.3. Cementation & curing modes

The composite blocks were next luted onto dentin following different curing modes (Table 1). The adhesives, either XTR or SBU, were applied on the dentin surfaces according to

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