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Composite cements benefit from light-curing

Anne-Katrin Lührs[a,b,*], Jan De Munck[a], Werner Geurtsen[b], Bart Van Meerbeek[a]

[a] KU Leuven – BIOMAT, Department of Oral Health Sciences, KU Leuven (University of Leuven) & Dentistry, University Hospitals Leuven, Belgium

[b] Department of Conservative Dentistry, Periodontology and Preventive Dentistry, Hannover Medical School, Hannover, Germany

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ABSTRACT

Objective. To investigate the effect of curing of composite cements and a new ceramic silanization pre-treatment on the micro-tensile bond strength (μTBS).

Methods. Feldspathic ceramic blocks were luted onto dentin using either Optibond XTR/Nexus 3 (XTR/NX3; Kerr), the silane-incorporated 'universal' adhesive Scotchbond Universal/RelyX Ultimate (SBU/RXU; 3M ESPE), or ED Primer II/Panavia F2.0 (ED/PAF; Kuraray Noritake). Besides 'composite cement', experimental variables were 'curing mode' ('AA': complete auto-cure at 21 °C; 'AA*': complete auto-cure at 37 °C; 'LA': light-curing of adhesive and auto-cure of cement; 'LL': complete light-curing) and 'ceramic surface pre-treatment' ('HF/S/HB': hydrofluoric acid ('HF': IPS Ceramic Etching Gel, Ivoclar-Vivadent), silanization ('S': Monobond Plus, Ivoclar-Vivadent) and application of an adhesive resin ('HB': Heliobond, Ivoclar-Vivadent); 'HF/SBU': 'HF' and application of the 'universal' adhesive Scotchbond Universal ('SBU'; 3M ESPE, only for SBU/RXU)). After water storage (7 days at 37 °C), ceramic–dentin sticks were subjected to μTBS testing.

Results. Regarding the 'composite cement', the significantly lowest μTBSs were measured for ED/PAF. Regarding 'curing mode', the significantly highest μTBS was recorded when at least the adhesive was light-cured ('LA' and 'LL'). Complete auto-cure ('AA') revealed the significantly lowest μTBS. The higher auto-curing temperature ('AA*') increased the μTBS only for ED/PAF. Regarding 'ceramic surface pre-treatment', only for 'LA' the μTBS was significantly higher for 'HF/S/HB' than for 'HF/SBU'.

Significance. Complete auto-cure led to inferior μTBS than when either the adhesive (on dentin) or both adhesive and composite cement were light-cured. The use of a silane-incorporated adhesive did not decrease luting effectiveness when also the composite cement was light-cured.

1. Introduction

Indirect ceramic restorations became more popular during the last years because of their superior esthetics, biocompatibility and long-term stability. So-called 'etchable' feldspathic (and glass-) ceramic restorations should be adhesively luted; it improves the fracture resistance and consequently enhances the survival rate [1]. Possible curing modes of composite cements are 'dual-cure', involving also

* *Corresponding author at*: KU Leuven – BIOMAT, Department of Oral Health Sciences, KU Leuven (University of Leuven) & Dentistry, University Hospitals Leuven, Belgium/Department of Conservative Dentistry, Periodontology and Preventive Dentistry, Hannover Medical School, OE 7740, Carl-Neuberg-Straße 1, 30625 Hannover, Germany. Tel.: +49 532 4718; fax: +49 532 4811.
E-mail address: Luehrs.Anne-Katrin@mh-hannover.de (A.-K. Lührs).

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light-curing, and 'auto-cure'. The beforehand applied adhesive, if any (not in case of self-adhesive composite cements), can be separately light-cured on the condition that its film thickness is sufficiently thin and does not impair the restoration fit. When adhesively luted ceramic restorations are light-cured, both the adhesive and cement may however not cure completely due to light attenuation, caused by the opacity of the restoration, its shade, and/or simply its thickness, the latter obviously related to cavity depth [2,3]. A ceramic thickness of 2–3 mm is considered to be the threshold to still effectively light-cure adhesively luted ceramic restorations [4,5]. Up to a thickness of 2 mm, there was according to Akgungor et al. [6] no effect of both ceramic thickness and polymerization mode on bond strength. For thicker restorations of 4 mm, a lower micro-tensile bond strength (μTBS) was detected [2]. Light attenuation already starts at a composite thickness of 1 mm, as the light intensity was reduced about 85%, and restorations of 4 mm thickness blocked the light almost completely [7]. It was also reported that light-curing the adhesive and the composite cement separately improved the bond strength to dentin [2,8]. Furthermore, auto-curing was found to influence the degree of conversion (DC) of composite cements and their mechanical properties [9–11]. Depending on the material, the bond strength of composite cements that were allowed to auto-cure was inferior to when they were light-cured [12–16].

Apart from the curing mode, the μTBS of composite cements may also depend on how the ceramic surface is pre-treated. Besides the strength of the dentin–cement interface also that of the cement–ceramic interface will contribute to the overall strength of the bond of the indirect restoration to the tooth [17,18]. Well accepted and most reliable is the etching of (feldspathic) ceramic with hydrofluoric acid (HF) followed by silanization. This pre-treatment provided the highest shear bond strength for four different cements and appeared also to remain stable six months after cementation [18]. Silanization after etching with HF appeared also to be the decisive step in a study by Filho et al. [19], because HF-etching only, without separate silanization, resulted in a significantly lower μTBS. Ikemura et al. [20] developed different experimental 'multi-purpose' adhesives with an incorporated silane; they were claimed to bond to various dental materials, including ceramics and metal alloys. The 30 wt.% silane-incorporated formulations bonded more effectively than those without silane [20]. Likewise, a so-called 'universal' adhesive with incorporated silane was recently introduced (Scotchbond Universal, 3M ESPE, Seefeld, Germany; SBU); it is claimed to be effective for bonding to both tooth surfaces and ceramics, the latter without the need of an additional and separate silane primer.

Although numerous studies reported on luting effectiveness, interactions of different factors involved in adhesive luting and their relative importance remain unclear. Therefore, the purpose of this study was to determine the effect of curing mode on the μTBS of composite cements to dentin and to evaluate a new ceramic surface pre-treatment using a silane-incorporated, so-called 'universal' adhesive. Therefore, the first hypothesis tested was that there was no significant difference in μTBS among the different experimental groups that varied for 'composite cement' and 'curing mode' (1). In addition, the second hypothesis tested was that the auto-cure temperature (room vs. body temperature) did not influence the μTBS (2). Finally, the third hypothesis tested was that the μTBS was not influenced by the ceramic surface pre-treatment (3: HF-etching followed by silanization and application of an unfilled adhesive, vs. HF-etching followed by application of a silane-incorporated adhesive).

2. Materials and methods

Dentin surfaces of 88 human 3rd molars were prepared as described by De Munck et al. [21] and randomly assigned to one of the 15 experimental groups. For the luting procedure, three different 'self-etch' composite cements were used: Nexus 3 combined with Optibond XTR (XTR/NX3; Kerr, Orange, USA), RelyX Ultimate with Scotchbond Universal (SBU/RXU; 3M ESPE) and Panavia F2.0 with ED Primer II (ED/PAF; Kuraray Noritake, Tokyo, Japan) (Table 1).

2.1. *Ceramic surface pre-treatment (Table 2)*

Feldspathic ceramic blocks (10.3 mm × 9 mm with a thickness of 3 mm; Vitablocs Mark II for CEREC/inLab, Vita, Bad Säckingen, Germany) were pre-treated with hydrofluoric acid ('HF': IPS Ceramic etching gel, Ivoclar-Vivadent, Schaan, Liechtenstein) for 60 s. Next, two different ceramic pre-treatment protocols were applied. For the XTR/NX3 and ED/PAF, a silane primer ('S': Monobond Plus, Ivoclar-Vivadent) was applied and left untouched for 60 s, followed by the application of an unfilled bonding agent ('HB': Heliobond, Ivoclar-Vivadent) that was not light-cured. This ceramic surface pre-treatment is further being referred to as 'HF/S/HB'. For SBU/RXU, the ceramic surface of each block was divided into two parts (5.15 mm × 9 mm) by cutting a shallow, approximately 1 mm deep groove using a diamond saw. A razorblade was inserted into the groove in order to separate the two surfaces from each other and to allow different surface pre-treatments to be applied to each part. Then, one side of the surface was treated with the silane primer and adhesive resin following the protocol described above and being referred to as 'HF/S/HB', while the other side received the silane-incorporated adhesive Scotchbond Universal (3M ESPE) only, thus without the application of a separate silane primer. The latter ceramic surface pre-treatment is further being referred to as 'HF/SBU'. In order to directly compare the two different pre-treatment methods ('HF/S/HB' vs. 'HF/SBU') per tooth, each ceramic block of the SBU/RXU group received two treatments (separated by the groove and temporarily by the razorblade) and was then luted to one tooth.

2.2. *Curing modes (Table 3)*

The ceramic blocks were luted onto the dentin surfaces following four different curing modes. Following curing mode 'AA', the adhesive applied on dentin was not light-cured after application, but air-thinned according to the manufacturer's instructions. The ceramic blocks were luted using the composite cements under a constant seating force of 1 kg for 1 min for