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Improved dentin bonding of core build-up composites using Visalys Core

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Introduction

Indirect adhesive tooth-colored restorations proved to be durable in the oral cavity[1-9]. Although some clinical trials reported bulk fractures to be the main failure reason here, clinical success is still striking[2-4,10-13]. Clinical trials reveal a certain deterioration of marginal quality[14], however, when adhesive inlays are totally bonded to enamel and dentin, also internal dentin bond strength is an interesting factor for both stabilization and reduction of postoperative hypersensitivities[2,15,16]. The same is true for adhesive build-ups prior to preparation, their role in sealing dentin and preventing postoperative hypersensitivities is certainly important.

It is still not fully understood how and in which content dual-cured build-up materials negatively interfere with ligh-cured all-in-one adhesives, however it is well-known that there is a lack of bonding quality[2,3,16-18]. Therefore, the aim of the present in vitro study was to evaluate the performance of a novel intrinsic adhesion connector for bonding of bulk-filled build-up resin composites.

Materials and methods

300 intact, non-carious, unrestored human third molars were stored in an aqueous solution of 0.5% chloramine T at 4°C for up to 30 days. The teeth were debrided of residual plaque and calculus, and examined to ensure that they were free of defects under a light microscope at 20x magnification. Standardized Class I cavity preparations (4mm in width and length, 4mm in depth) were performed. Cavities were cut using coarse diamond burs under profuse water cooling (80 µm, Two-Striper® Prep-Set, Premier, St. Paul, USA), and finished with a 25 µm finishing diamond. Inner angles of the cavities were rounded and the margins were not

bevelled. To guarantee a rectangular relation between the bonded interface and the direction of the later cut μ-TBS beam, the cusps were flattened 2 mm and then the cavity floor was prepared parallel to the flattened cusps.

Cavities were overfilled 5 mm in bulk with different adhesives and core build-up materials under elevated room temperature (30°C for simulation of intraoral temperature). The adhesives were: Exp. I/II (Kettenbach), OptiBond FL (Kerr), Scotchbond Universal Bond (with and without activator; 3M Espe), AdheSE Universal (Ivoclar Vivadent), AllBond Universal (Bisco), Futurabond Universal (Voco), Xeno Select (Dentsply), Clearfil SE Bond/Clearfil S3 Bond Plus (Kuraray), iBond SE (Kulzer Dental). The build-up resin composites were: Visalys Core (Kettenbach), Luxacore Smart-Mix (DMG), Core Paste XP (DenMat), Multicore Flow (Ivoclar Vivadent), Rebilda DC (Voco). Adhesives (separately cured according to the instructions of the manufacturers) and build-up resin composite were polymerized with a Bluephase light-curing unit (Ivoclar Vivadent) in accordance to the manufacturers' recommendations. The intensity of the light was checked periodically with a radiometer (Demetron Research Corp, Danbury, CT, USA) to ensure that 1200 mW/cm^2 was always exceeded during the experiments.

After 24 h of water storage at 37°C and 2,500 thermocycles (5°C/55°C), the peripheral areas of the reconstructed/filled teeth were removed, remaining specimens were sectioned into slices in apical direction, which were sectioned again to receive resin-dentin beams. The saw was adjusted to steps of 1 mm, due to the thickness of the blade (300 μm) resulting in sticks with a cross-sectional area of 700 x 700 μm (0.5 mm^2). From the resulting sticks of each group, 20 were selected (n=20). These 20 sticks had to have a remaining dentin thickness to the pulp of 2.0 $\pm$ 0.5 mm. If more than 20 beams were collected with the correct remaining

dentin thickness, 20 sticks were randomly selected. For the case that one or more of the selected sticks failed due to the sectioning process, the percentage of prematurely failed specimens in relation to the total number of selected specimens was recorded. The same (or approximated) percentage of the 20 final specimens received 0 MPa as final μ-TBS result[22]. The μTBS sticks were stored in distilled water for 24 hours at 37°C and then fractured according to a well-suited protocol[23]. Fractured interfaces were submitted to Scanning Electron Microscopy (Phenom, FEI, Amsterdam, The Netherlands).

Statistical analysis was performed using SPSS, Version 14.0 for Windows XP (SPSS Inc., Chicago, IL, USA). As the majority of groups did not exhibit normal data distribution (Kolmogorov-Smirnov test), non-parametric tests were used (Wilcoxon matched-pairs signed-ranks test, Mann-Whitney-U test) for pairwise comparisons at the 95% significance level.

Results

Visalys Core showed a general positive effect on dentin bond strength with all adhesives ($p<0.05$). Except with the 3-step adhesive OptiBond FL, the build-up composites Luxacore Smart-Mix, Core Paste XP, Multicore Flow, and Rebilda DC had no dentin adhesion throughout the experiments ($p<0.05$). An overview of results is given in the following table:

Adhesive	Build-up resin composite	μTBS [MPa](SD)
Exp. 1	Visalys Core	9.2 (4.3)
	MultiCore Flow	3.2 (0.9)
	Rebilda DC	4.1 (1.3)
	Luxacore Dual	0
	Core Paste XP	0
Exp. 2	Visalys Core	11.5 (5.6)
	MultiCore Flow	4.1 (1.3)
	Rebilda DC	4.0 (2.6)
	Luxacore Dual	0
	Core Paste XP	0
AdheSE Universal	Visalys Core	5.2 (4.6)
	MultiCore Flow	0
	Rebilda DC	0

	Luxacore Dual	0
	Core Paste XP	0
All-Bond Universal	Visalys Core	7.4 (4.6)
	MultiCore Flow	0
	Rebilda DC	0
	Luxacore Dual	0
	Core Paste XP	0
Clearfil S3 Bond Plus	Visalys Core	20.3 (6.7)
	MultiCore Flow	0
	Rebilda DC	0
	Luxacore Dual	0
	Core Paste XP	0
Clearfil SE Bond	Visalys Core	21.3 (6.4)
	MultiCore Flow	0
	Rebilda DC	0
	Luxacore Dual	0
	Core Paste XP	0
Futurabond U	Visalys Core	5.2 (6.0)
	MultiCore Flow	0
	Rebilda DC	0
	Luxacore Dual	0
	Core Paste XP	0
OptiBond FL	Visalys Core	24.3 (5.9)
	MultiCore Flow	15.6 (4.5)
	Rebilda DC	20.6 (5.4)
	Luxacore Dual	14.2 (5.6)
	Core Paste XP	5.6 (3.5)
Scotchbond Universal with Activator	Visalys Core	0
	MultiCore Flow	0
	Rebilda DC	0
	Luxacore Dual	0
	Core Paste XP	0
Scotchbond Universal without Activator	Visalys Core	9.4 (5.0)
	MultiCore Flow	0
	Rebilda DC	0
	Luxacore Dual	0
	Core Paste XP	0
Xeno Select	Visalys Core	11.2 (4.7)
	MultiCore Flow	0
	Rebilda DC	0
	Luxacore Dual	0
	Core Paste XP	0
iBond SE	Visalys Core	5.6 (4.3)
	MultiCore Flow	0
	Rebilda DC	0
	Luxacore Dual	0
	Core Paste XP	0

Discussion

Clinical survival of indirect restorations may be fundamentally dependent on durable enamel bonding, however, a tight dentin seal being promoted by durable dentin bonding of core-build-up materials is also essential [1,2,15,18]. Thus, the present study exclusively focussed on internal dentin bond strength beneath core build-ups in order to elucidate potential weak links that were previously described[18,20,24,25].

Hikita et al. evaluated enamel and dentin bond strengths of luting systems for adhesive inlays. It was remarkable that Syntac and Variolink II without separate light-curing of the adhesive obtained no dentin bond strength in the whole investigation[26]. This may be surprising, because especially this particular combination of light-curing adhesive and dual-curing luting resin composite has been repeatedly reported to be clinically effective[1,2,15]. The same is true for reported incompatibility of self-etch all-in-one adhesives and dual-cured resin composites for core build-up.

The potential of core build-up prior to preparation has the beneficial effect that contamination with temporary cements is avoided and appropriate polymerization of the resin-dentin interface is guaranteed[19,20,24,25,28,29]. However, this is only true when the adhesive really reacts with the build-up material. This seems to be the case in all tested adhesives when Visalys Core was used for core build-up.

The chosen experimental set up is certainly extreme. The combination of maximum c-factor and 5 m bulk fill leads to the highest polymerization stresses thinkable. On the other hand, also several clinical situations are characterized by extreme scenarios, therefore we certainly see clinical relevance here.

Conclusions

The intrinsic adhesion connector in Visalys Core (ACT: Active Connect Technology) seems to overcome the traditional weak link between dual-cured resin composites for core build-up and self-etch all-in-one adhesives and showed a promising performance in an extreme shrinkage scenario.

For the other adhesives / build-up resin composites this does not mean that these adhesives do not function under normal conditions, however, under the present maximum C-factor surrounding combined with a 5 mm overfill / bulk-fill technique, these materials were not able to produce measurable dentin bond strengths to cavity floor dentin anymore when dual-cured build-up composites were used 5 mm in bulk.

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