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Push-out bond strength evaluation of Visalys Core in root canals

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Introduction

Clinical trials of endodontically treated teeth restored with adhesively-luted fiber reinforced composite posts (FRC posts) revealed promising results.[1, 2] However, a recently published observational clinical study exhibited annual failure rates of 4.6 %.[3] The most frequently occurring failure modes were post debonding and post fracture. Consequently, it can be concluded that bonding of posts to root canal dentin is still a challenge due to limited access, visibility, moisture control, reduced number of dentinal tubules in the apical third of the root, and deposition of cementum and secondary dentin.[4] In addition, the C-factor inside the root canal has been shown to be extremely high.[5] Therefore, the achievement of reliable bonding and effective adhesion inside the root canal is still is issue of interest.[5, 6] Another crucial question in that context is how high in vitro bond strengths have to be to more or less guarantee clinical success with the individually tested material.

With the aim to analyze effective hybridization of several adhesive and luting systems to dentin confocal laser scanning microscopy (CLSM) has been used for the investigation of the distribution of primer, adhesive and resin cement inside the hybrid layer and the dentinal tubules.[7-10] An advantage for clinical application of fiber posts would be to combine luting of the fiber post inside the root canal and performing the core build-up in a one-stage procedure. Consequently, various manufacturers provide post-and-core systems and recommend the above mentioned procedure. This combination has been described as a secondary monoblock;[6] however, a previous study pointed out possible negative effects of core materials for luting fiber posts due to the higher filler content.[11]

Post-and-core-systems are available with different adhesive approaches, i. e. self-etching or etch-and-rinse approach. Evaluation of both adhesive approaches for bonding fiber posts inside the root canal revealed conflicting results with either no difference between the systems,[12] higher performance of self-etching adhesives[13] or higher bond strength for the etch-and-rinse approach compared to the self-etching approach.[14] The aim of the present study was to investigate bond strength of Visalys Core to root canal dentin.

Methods and Materials

Specimen preparation:

130 sound human maxillary central incisors were stored in 0.5 % chloramine solution for at least one year after extraction. All patients were informed that their extracted teeth are used for scientific research and all patients gave their consent verbally. The crowns of the teeth were sectioned at the proximal cemento-enamel junction using a diamond blade under constant water cooling. Root canal preparation was performed at a working length of -1 mm from the apical foramen using MTwo and FlexMaster rotary instruments (VDW, Munich, Germany) up to size .02/50; the canals were filled with warm, vertically condensed BeeFill®2in1 gutta-percha (VDW) and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany), and stored in water for 24 h.

The specimens were randomly divided into 13 groups of 10 teeth each: Visalys Core was bonded with exp. adhesive I/II (Kettenbach), OptiBond FL (Kerr), Clearfil SE Bond, Clearfil S3 Bond (both Kuraray), Scotchbond Universal Bond with activator/without activator (3M Espe), AdheSE Universal (Ivoclar Vivadent), AllBond Universal (Bisco), Futurabond U (Voco), Xeno Select (Dentsply), iBond SE (Kulzer Dental). RelyX Unicem (3M Espe) served as control.

Root canals were enlarged with a slow-speed drill provided by the manufacturer of the selected post-and-core system. The depth of the post space preparation was 8 mm. Irrigation after post space preparation was performed using 5 mL 0.9 % NaCl solution; posts (Core and post system, Dentsply) were tried-in and inserted. The core materials were applied onto the posts' surfaces and into the orifice of the root canals and the posts were inserted into the canal. Excess was removed, and light curing was performed using a LED curing unit [1200 mW/cm^2; Bluephase (Ivoclar Vivadent)] according to the manufacturers' recommendations. Light intensity of the light curing unit was checked prior to use (LED Radiometer; Demetron, Kerr, Orange, CA, USA).

Push-out testing:

After the microscopic analysis a 1 mm thick slice was cut off from each sample using a band saw (Exakt Apparatebau) under constant water cooling and micro push-out testing was performed (Universal testing machine Zwick; Roell, Ulm, Germany) at a cross-head speed of 0.5 mm/min. [15-17]

Statistical appraisal:

Statistical analysis was performed using IBM SPSS version 19.0 software (SPSS, Chicago, IL, USA). The alpha (Type I) error level was set to 0.05. One tooth was considered as a statistical unit; consequently data were aggregated using the break variables tooth and location. A repeated measurement ANOVA with the inter-individual factors material and incorporation of fluorescent dyes was applied at four (G RB, LC, CX, MC) and two levels (yes/no) and location as intra-individual factor (coronal, middle, apical) was applied. To examine differences between materials Tukey's post-hoc test was used. Analysis of the failure modes was conducted using crosstabs and Chi-square test.

Results

Adhesive	**Push-out bond strength [MPa](SD)**
Exp. I	12.5 (3.5) [A]
Exp. II	12.8 (2.8) [A]
OptiBond FL	10.4 (4.4) [A]
Clearfil SE Bond	10.5 (4.6) [A]
Clearfil S3 Bond	11.5 (6.7) [A]
SBU w Activator	8.5 (5.1) [B]
SBU w/o Activator	11.2 (3.6) [A]
AdheSE Universal	9.5 (3.9) [AB]
All Bond Universal	10.8 (5.6) [A]
Futurabond Universal	10.2 (4.1) [A]
Xeno Select	10.8 (5.2) [A]
iBond SE + VC	9.5 (3.8) [AB]
RelyX Unicem	13.5 (5.6) [A]

Discussion

This investigation focused on push-out bond strengths of different adhesives combined with different core build-up materials for adhesive luting. Morphological characteristics of the resin-dentin interface were not evaluated.[10, 18]

The smear layer produced by motorized preparation such, as with post drills has been demonstrated to be greater in volume compared to hand filing of the root canal.[22] Irrigation after post space preparation was carried out with NaCl solution in the present study; consequently, no effective smear layer removal could be expected prior to the application of the investigated adhesive systems. In order to be consistent between the groups one irrigation protocol for all investigated systems irrespective of the manufacturers' recommendations was applied. Although some manufacturers (e.g. Ivoclar Vivadent for Adhese Universal) of the investigated systems recommend NaOCl after post space preparation, NaCl was used as final rinse in order to avoid any effects of the irrigation protocol on bond strength, because the effects of NaOCl as a final rinse on bond strength have been discussed controversially.[23-26]

It has been reported that smear layer denseness may compromise dentin bonding more than smear layer thickness, especially for self-etch adhesives.[27] Previous results indicate successful smear layer modification for the investigated self-etch adhesive systems, since a thinner (compared to etch-and-rinse adhesives), but continuous hybrid layer was detected inside the root canal.

The use of activators in the cited study increased the density and quality of resin tags for all types of the investigated adhesive systems significantly. However, in the present study not all adhesive systems under investigation were dual-cured by mode. Fifth-generation dual-polymerizing bonding agents contain coinitiators, such as benzene sulfinic acid sodium salt.[29] The initiator-catalyst system should promote adhesion of compatible dual-curable resin-based luting agents to the adhesive layer and accelerate their polymerization.[30] Consequently, differences in light transmission ability of the investigated posts[31] should not hamper the bonding performance of the systems.

Main falsifying factor of the present investigation was light transmission through root canal posts. However, this was only a problematic factor in the cervical specimens. When substantial problems

with light curing occurred, apical parts of the specimens gave no PBS results. Finally, the thin push-out test again proved to be a valid method to analyze bond strengths of fiber posts to root canal dentin.[34]

Bond strength of the investigated post-and-core systems inside the root canal differed. A previous study also showed no difference in bond strength between self-etch and etch-and rinse adhesives inside the root canal[12], whereas others reported lower bond strength for etch-and-rinse adhesive systems compared to self-etch adhesives.[10, 13] In contrast, another study showed lower bond strength for the self-etch approach compared to the etch-and-rinse or self-adhesive approach.[14] These conflicting results imply that bond strength inside the root canal is more product-dependent than affected by the adhesive approach. In contrast to previous investigations, where more kinds of fiber posts were used, we used only one type, because it was shown that push-out bond strength was more dependent on the type of fiber post than on the type of the luting agent used.[37] This corresponds to the observed failure modes, most failures were adhesive between dentine and core material as described previously for push-out bond strength analyses inside root canals.[10, 12-14] Adhesive failures between post and core material were observed to a lesser extent in the present investigation, showing a good compatibility between posts and core material.

It has been reported previously that one stage postendodontic restorations allowing simultaneous post cementation and core fabrication might be detrimental due to higher polymerization stress and reduced bond strength because of the increased percentage of fillers being necessary for core build-up materials.[11] However, in the present investigation the investigated post-and-core systems demonstrated comparable bond strength values irrespective of the filler content of the core materials with clear advantages for Visalys Core as monoblock system.

Conclusions

The intrinsic adhesion connector of Visalys Core worked well in root canals. The crucial threshold of 10 MPa push-out bond strength was always obtained during the experiments.

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