Article

Particulate Filler and Discontinuous Fiber Filler Resin Composite´S Adaptation and Bonding to Intra-Radicular Dentin

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Abstract: This study was aimed at assessing adaptation and bonding of discontinuous (short) glass fiber-reinforced composite to intraradicular dentin EverX Flow (GC Corporation, Tokyo, Japan), when used as intracanal composite filling and anchorage instead of traditional fiber posts. (2) **Methods**: Seventy intact extracted human teeth were endodontically treated and randomly divided into 6 groups (n=10), depending on the materials used in the post space. In Group 1, a 2-bottle universal adhesive G2 Bond Universal + EverX Flow were tested. In group 2, a single-component universal adhesive G-Premio Bond + EverX Flow were used. In groups 3 and 4 the same materials are tested, but after cleaning of the canal walls with 17% EDTA and final irrigation with 5.25% NaOCl Ultrasound Activated. In the last three Groups (5-7) traditional prefabricated GC Fiber Posts 1.6 mm silanized with G-Multi Primer for 1 minute are cemented with a dual-cured composite resin cement (GradiaCore), after ultrasonic irrigation in the groups 6 and 7. In each group, 1 mm-thick slices from each sample (n=10) were cut for light microscope and SEM inspection for study materials adaptation to the dentin and for measuring push-out strength of post / cemement material to the dentin / prefabricated post. These results were statistically analyzed: as the data distribution was not normal, the Kruskal-Wallis Analysis of Variance by Ranks had to be applied. The level of significance was set at $p<0.05$. **Results:** Push-out forces varied between 6.66-8.37 MPa. No statistically significant differences were recorded among the groups. Microscopic examination showed that ultrasonic irrigation increased adaptation of the materials to the dentin surface. There was a trend of higher bond strength among the tested groups when EverX Flow was used. Also, the type of failure was more often cohesive when ultrasonic irrigation and two-step adhesive system were used. **Conclusions:** Within the limitations of this in vitro study, it may be concluded that when EverX Flow was used for intracanal anchorage in the post-endodontic reconstruction, similar push-out retentive forces and strength to those of traditional fiber posts cemented with particulate filler resin composite cements were achieved. Although further studies are necessary, EverX Flow represents an effective alternative to traditional fiber post adhesion in particular when used in combination with the two-step adhesive system and ultrasonic activation.

Clinical significance EverX Flow, discontinuous short glass fiber-reinforced composite originally proposed for dentin replacement in direct restorations and for core build-up, represents a viable and operatively simpler alternative to traditional fiber post adhesion in endodontically-treated teeth.

Keywords: Fiber-reinforced composite post; Short-glass fiber reinforced composite; Endodontically-treated teeth; Intra-radicular adhesion; Push-out bond strength

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1. Introduction

The success of endodontic treatment is linked to the adequate sealing by the coronal restoration and root canal post material which are used to reestablish function and aesthetic [1]. Endodontically treated (ET) teeth are structurally different from non-restored vital teeth [2]. This structural fragility is due to pathology, access cavity preparation, excessive removal of dentine during root canal treatment, rather than reduced tissues moisture [3] and absence of cross-linking between dentinal collagen [4]. The loss of strategic components (i.e., ridges, supporting dentin) is the main reason why ET teeth are vulnerable and show reduced resistance to fracture [5, 6]. Wu et al. observed an increase in cuspal deflection as a result of the removal of both marginal ridges in an MOD cavity preparation and in conjunction with an endodontic access cavity [7]. This is especially important in the case of ET maxillary premolars: these elements are exposed to a combination of shearing and compressive forces, which makes them especially prone to fracture [8]. Therefore, an adequate restorative approach must fulfill both esthetics and the structural preservation and reinforcement of these teeth, as well as providing a coronal seal to protect the endodontic system from bacterial infiltration of the oral cavity. The fiber-reinforced composite (FRC) posts have been widely investigated and used for the restoration of endodontic treated teeth with a significant loss of coronal tooth structure [9, 10]. To provide optimal retention and enhanced stress distribution within the root, particulate filler resin composite cements are used as luting agents [11]. The use of fiber-reinforced composite (FRC) posts has become popular to restore ET teeth, due to their favorable modulus of elasticity which is closer to that of dentine compared to metal posts [12, 13]. Several studies showed that inserting a post into ET premolars significantly increased their fracture resistance [14, 15]. However, the technique procedure of post placement is not devoid of risks [16] related in particular to the limits of intraradicular adhesion and the shrinkage stress maximum for the post (unfavorable C factor). Post debonding resulted the most frequent failure mode of post retained restorations in clinical trials [17].

Fiber-reinforced composites has been introduced with the claims of better mechanical properties, especially fracture toughness and curing stress behavior than traditional composites [18]. These materials provided post retention values comparable to traditional dual-cure resin composite cements [19,20]. In 2007, Garoushi et al. demonstrated a better load bearing capacity of discontinuous, i.e. short fiber reinforced composite (SFRC) as opposed to the application of an FRC post in root post-core system of severely damaged anterior ET teeth [21]. Forster et al. in ET premolar teeth with class I cavity showed statistically non-significant difference of directly layered fiber-reinforced composite post and core group compared to intact premolar teeth in terms of fracture resistance [22]. Based on this knowledge, it is important to obtain more detailed information on this fiber-reinforced post-core restorative approach. Thus, the aim of the present investigation is to assess, with the push-out test and microscopic examination, the bonding and adaptation characteristics to intraradicular dentin when short glass fiber-reinforced composite, Ever X Flow (GC Corporation, Tokyo, Japan) [23]. For the fiber-reinforced composite material, improved bonding and toughness properties have been reported, due to high aspect ratio glass fiber fillers and the formation of a semi-interpenetrating polymer network taking place during polymerization [18, 24]. The formulated null hypothesis was that EverX Flow restorations achieve bonding force to root canal comparable to those of traditionally cemented fiber posts.

2. Materials and Methods

Specimen preparation

Seventy single-rooted human teeth, extracted for periodontal or orthodontic reasons, were selected for the study. The freshly extracted teeth were disinfected in hydrogen peroxide solution for 5 min. The soft tissue covering the root surface was removed with hand scalers (Hu Friedy, Chicago, Il, USA). The inclusion criteria were the visual and radiologic absence of caries or root cracks, previous endodontic treatments, posts or crowns, resorptions. Teeth were numbered, radiographed and stored in physiological solution.

The access cavity preparation was carried out with a round-end diamond bur (No. #12; Coltene Whaledent, Altstätten, Switzerland) with water cooling and root canal treatment was performed. The root canal entries have been found through an endodontic probe DG16 (Hu Friedy, Chicago, Il, USA); the working length was established by introducing a number 10 K-file (Maillefer-Dentsply, Ballaigues, Switzerland) until it was visible through the apical foramen.

The canals were instrumented with a simultaneous preparation technique by the same operator using nickel-titanium rotary instruments Mtwo (Sweden & Martina) sequenced in order (10.04, 15.05, 20.05, 25.06), at the working length. The instruments were used at a speed of 250rpm, mounted on an endodontic motor (X-SMARTTM Plus; Dentsply Maillefer, Ballaigues - Suisse), selecting the ProTaper function in the settings. During preparation the canals were irrigated after every instrument with 5.25% NaOCl solution. Finally, manual gauging was performed with K-file of the same size as the last rotary instrument that worked at the apex and 5 mm of ethylenediaminetetraacetic acid at 17% (OGNA LAB S.r.l., MB, Italy) was left for a total time of two minutes; the final irrigation was then carried out with 5 mm of NaOCl at 5.25%.

The preformed cone of gutta-percha (Mtwo, Sweden & Martina) of the same diameter and taper of the last rotary instrument that worked in the apex was tested, checking for slight resistance (tug back). The canals were dried with paper cones (Dentsply Sirona).

Obturation was performed using a continuous wave condensation technique with gutta-percha cones (Mtwo, Sweden & martina) cut at the apex (0.5 mm) and a root canal cementation material based on zinc oxide/eugenol (Pulp Canal Sealer, Kerr). The cone was condensed and compacted 5 mm from the apex (down packing). Roots were then backfilled with thermoplastic injectable gutta-percha (Obtura, Meta systems EQ-V), then compacted with an endodontic plugger (Machtou 1-2. Dentsply Sirona, USA). Postoperative periapical radiographs were taken for all samples.

All root canal-treated teeth received a post space preparation: part of this filling material was removed with low-speed Number 5 and 6 Gates Glidden burs; the canal walls were enlarged with low-speed Number 5 and 6 Largo (Dentsply Maillefer) burs, leaving a minimum apical seal of 4–6 mm of gutta- percha in the canal. The postoperative x-rays were reperformed for the second time. The depth of the root canal space to be filled was till 4-5 mm to the anatomic apex. Chemical composition of the materials used in this study are reported in Table 1.

Table 1. Chemical composition of the materials used in the study.

Material	Composition
G-Premio Bond	10-MDP, 4-META, 10-MDTP, methacrylate acid ester, distilled water, acetone, photoinitiators, fine powdered silica
G2 Bond Universal	**Primer**: 4-META, MDP, dimethacrylate, photoinitiator, water, acetone, silica, MDTP **Bond**: Dimethacrylate, photoinitiator, silica
EverX Flow (SFRC)	Bis-EMA, TEGDMA, UDMA, micrometer scale glass fiber filler 100-300 μm and Ø7 μm, Barium glass 70 wt%, 46 vol%
Gradia Core	Methacrylic acid ester 20–30 wt%, fluoro-alumino-silicate glass 70–75 wt%, silicon dioxide 1–5 wt%.
GC Fiber Post	Glass fibers, dimethacrylate matrix
G Multi Primer	MPTMS, 10-MDP, MDTP, BisGMA, TEGDMA, Ethanol

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10-MDP, 10-methacryloyloxydecyl dihydrogen phosphate; 4-META, 4-methacryloxyethyl trimellitic anhydride; 10-MDTP, 10-methacryloxydecyl dihydrogen thiophosphate; UDMA, urethane dimethacrylate; TEGDMA, triethyleneglycol dimethacrylate; Bis-EMA, Ethoxylated bisphenol-A- dimethacrylate; Bis-MEPP, 2,2-bis(4 methacryloxypolyethoxyphenyl) propane; PMMA, polymethyl methacrylate; wt%, weight percentage; MPTMS, methacryloxypropyl trimethoxysilane; BisGMA, bisphenol-A glycidyl dimethacrylate,

Teeth were randomly divided into 7 groups, depending on the materials used in the post space:

1. G2 Bond Universal (GC Co.) + EverX Flow (GC Co.)
2. G-Premio Bond (GC Corporation Tokyo Japan) + EverX Flow (GC Corporation Tokyo Japan)
3. G2 Bond Universal (GC Co.) + EverX Flow (GC Co.) with Ultrasonic Activation.
4. G-Premio Bond (GC Co.) + EverX Flow (GC Co.) with Ultrasonic Activation.
5. G-Premio Bond (GC Co.) + a dual-cured composite resin cement (GradiaCore, GC Co.) + GC Fiber Post 1.6 mm (GC Co.), silanized with G-Multi Primer for 1 minute (GC, Co.)
6. G-Premio Bond (GC Co.) + a dual-cured composite resin cement (GradiaCore, GC Co.) + GC Fiber Post 1.6 mm (GC Co.), silanized with G-Multi Primer for 1 minute (GC Co.) with Ultrasonic Activation.
7. G2 Bond Universal + prefabricated FRC post (GC Co.) with Ultrasonic Activation.

In groups 1, 2, 5 the canal walls were cleaned with 17% EDTA for 30 s and final irrigation with 5.25% NaOCl. The same protocol was performed in groups 3, 4, 6, 7 but using Ultrasonic Activation of irrigant solutions (NEWTRON P5 XS; Satelec Acteon). The root canals were dried with paper points. The teeth received different adhesive treatments:

- In groups 1, 3 and 7 a two-bottle universal adhesive (primer + bonding) G2 Bond Universal (GC Co.) was used, according to the manufacturer's instructions. The primer solution was applied in the canal with a microbrush (GC Co.). Excess adhesive was removed from the post space with a gentle air blowing and absorbent paper points. After the bonding application, excess adhesive was removed by suction drying and light cured for 20 s using a LED light (VALO Cordless-LED Curing Light - Ultradent).
- In the other groups (2, 4, 5, 6), a one-bottle G-Premio Bond (GC Co.) universal adhesive was applied in a single step, the excess was removed with a gentle air blowing and the adhesive has been cured.

After light curing the adhesive, the teeth in groups 5-7 received a conventional translucent glass FRC post (GC Fiber Posts, GC Co.) of 1.6 mm diameter. The posts received silanization of the surface (G-Multi Primer, GC Co.), for 1 min following the manufacturer's recommendation. Luting of the posts was performed with a dual-cured composite resin cement (Gradia Core, GC Co.). Gradia Core was applied using its own automix cartridge. The post was seated with a slight finger pressure. The cement excess was removed by cotton pellets and light-cured through the post for 20 s with a LED light keeping the light tip in contact to the end of the post.

In the other groups (1, 2, 3, 4) no fiber posts were used whereas after the application the adhesive system, the short glass fiber-reinforced composite (SFRC) Ever X Flow (GC Co.) was injected into the post space with the use of EverX compule and light-cured for 20 s keeping the light tip in contact to the coronal opening of the cavity.

In order to reduce possible bias, all the restorative procedures were performed by the same operator.

Push-out loading test

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Crowns were removed at the cement-enamel junction (CEJ), using a water-cooled diamond disc (Isomet, Buehler). All the roots were sectioned perpendicularly to their long axis by means of an Isomet saw under water cooling (Buehler), providing 1 mm thick slices for each sample and the slides were made starting 2 mm below the CEJ.

To evaluate the bonding properties, the push-out test was performed using an universal testing machine (Triax 50, Controls SPA, Milano, Italia), at a cross-head speed of 0.5 mm min until bond failure occurred, as manifested by the extrusion of the post/composite segment from the root slice. On the loading machine each slice was positioned with the apical side of the segment facing the plunger tip, so as to apply the loading force in the apical-coronal direction. The plunger tip was sized and positioned to touch only the post or the composite, without stressing the surrounding root canal walls. Testing was made for water-conditioned samples at room temperature.

A digital caliper with 0.01 mm accuracy was used to measure the thickness of each slice, as well as the coronal and apical diameters of the posts/composites. The retentive force was measured and corresponding bond strength of the post segment was expressed in MPa, by dividing the load at failure in Newtons and the bonded interfacial area (A, mm^2) of the post fragment. The interfacial area was calculated as the lateral surface of a truncated cone using the formula $A=\pi(R+r)[h^2+(R-r)^2]^{0.5}$, where $\pi = 3.14$, R is the coronal post radius, r is the apical post radius and h is the thickness of the slice.

Microscopic Analysis

In addition, to observe the type of failure at the adhesive interfaces and post-curing adaptation-of adhesive resin or luting cement in the different groups, the specimens were firstly visually examined under a stereomicroscope (Nikon H550L, Nikon, Tokyo, Japan) and then subjected to scanning electron microscopy (SEM) observation. Prior to SEM observation, all the specimens were gold-coated using a sputter coater in a vacuum evaporator (Emitech K550 Sputter Coater).

Statistical analysis

As the data distribution was not normal, the Kruskal-Wallis Analysis of Variance by Ranks had to be applied. The level of significance was set at $p<0,05$ and calculations were performed using the SigmaPlot software for Windows (version 11.0).

3. Results

Results of push-out force (N) and strength (MPa) to debond the material from the root canal dentine are reported in Table 2. Type of failure is reported in Table 3.

Table 2. Descriptive statistics of push-out force (in N) in the groups.; Kruskal–Wallis tests revealed no statistically significant differences among the groups (p=0,902).

Group	N	Median	Interquartile Range
1	44	7,35	5,35-11,11
2	38	6,66	5,87-8,75
3	36	8,37	6,46-10,55
4	43	7,72	5,34-10,71
5	33	7,14	4,65-10,31
6	42	6,78	4,49-13,59
7	39	7,99	4,62-8,92

Table 3. Type of failure: N: number of samples; A: Adhesive failure at the dentin-cement interface; C: Cohesive failure within the restorative material; M: Mixed failure at the dentin-cement interface and cement-restorative material interface.

Group	N	A	C	M
1	44	20	/	24
2	38	23	/	15

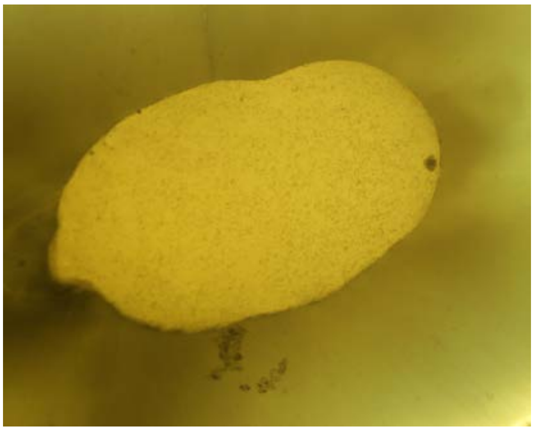
3	36	10	7	19
4	43	18	2	23
5	33	14	/	19
6	42	12	1	29
7	39	22	4	13

Group 1: G2 Bond Universal + EverX Flow. Group 2: G-Premio Bond + EverX Flow. Group 3: Ultrasonic Activation of EDTA and NaOCl (UA)+ G2 Bond Universal + EverX Flow. Group 4: UA + G-Premio Bond + EverX Flow.Group 5: G-Premio Bond + prefabricated FRC post. Group 6: UA + G-Premio Bond + prefabricated FRC post. Group 7: UA + G2 Bond Universal + prefabricated FRC post.

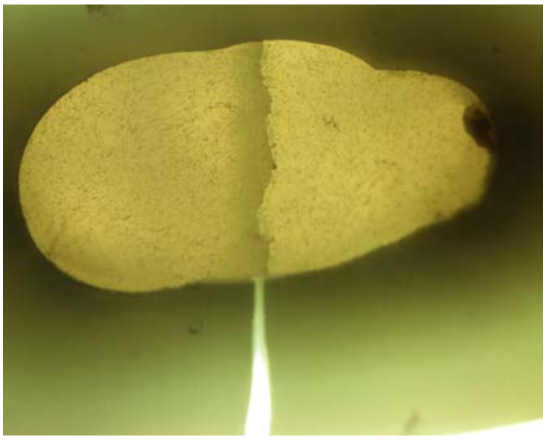
Kruskal–Wallis tests revealed no statistically significant differences among the groups (p=0,902). In general, the group 3 recorded the highest values of bond strength, while group 2 recorded the lowest values.

Microscopic observations are shown in Figs. 1A-1G and 2A-2G. Cohesive failures were noted only when ultrasonic activation was used (Figs. 1B, 1E). In all other groups type of failures was distributed between adhesive (Fig. 1D) and mixed (Fig. 1C).

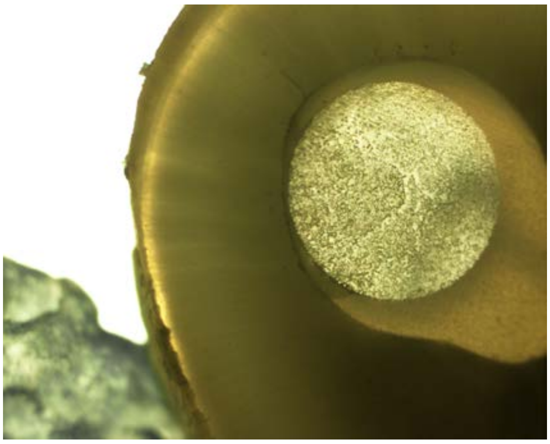
Figures 1A-1G



Figures 1A Group 1: EverX Flow filled the root canal properly well.



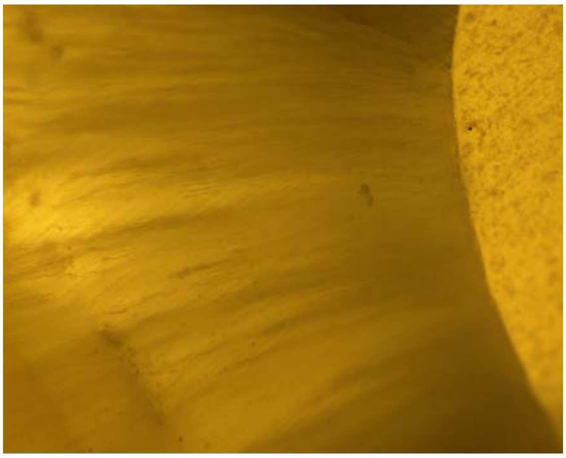
Figures 1B Group 2: Cohesive failure of EverX Flow under loading.



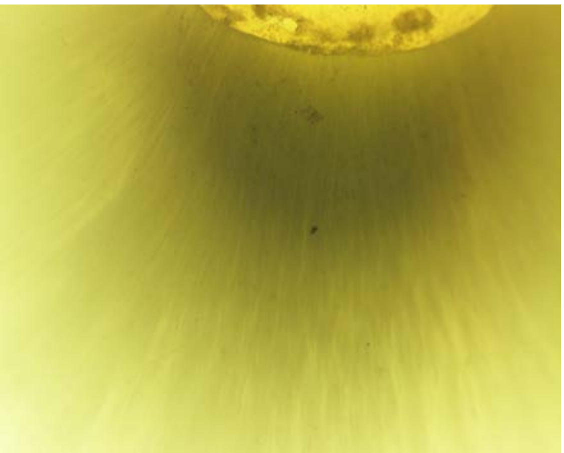
Figures 1C Group 3: Thick thickness of cement between the post and the radicular dentin.

Figures 1D Group 4: Adhesive failure at the interface between radicular dentin and EverX Flow.

Figures 1E Group 5: Cohesive failure of a fiber post.

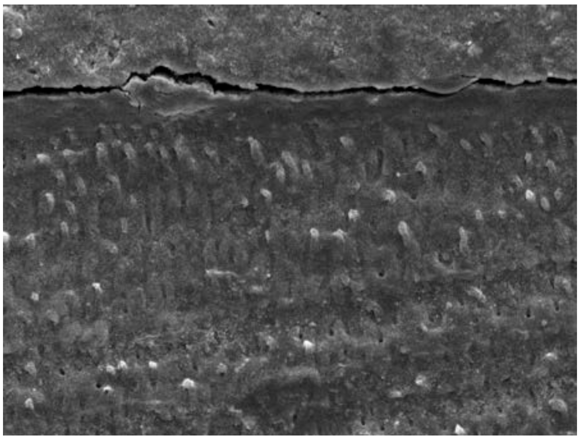


Figures 1F Group 6: The material has adapted well to the dentin surface. (G-Premio Bond adhesive system after Ultrasonic Activation).

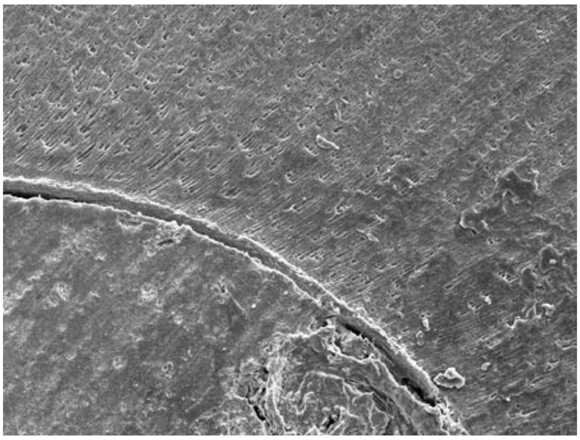


Figures 1G Group 7: The resin material penetrating deeply into the dentinal tubules (G2 Bond adhesive system after Ultrasonic Activation).

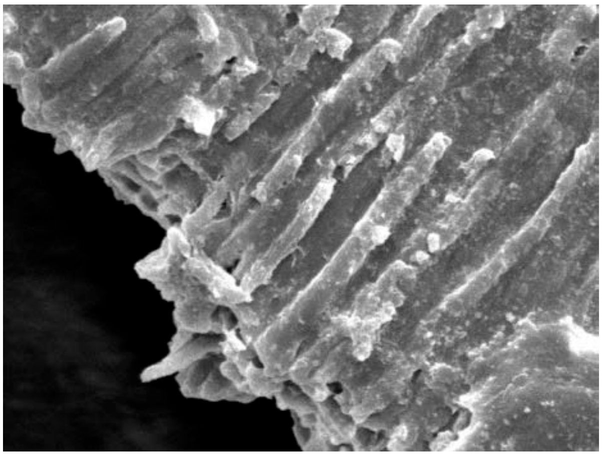
The microscopic analysis showed improved post-curing adaptation of luting materials in the ultrasonically activated groups (Figs.1F-1G, 2A-D, 2F).



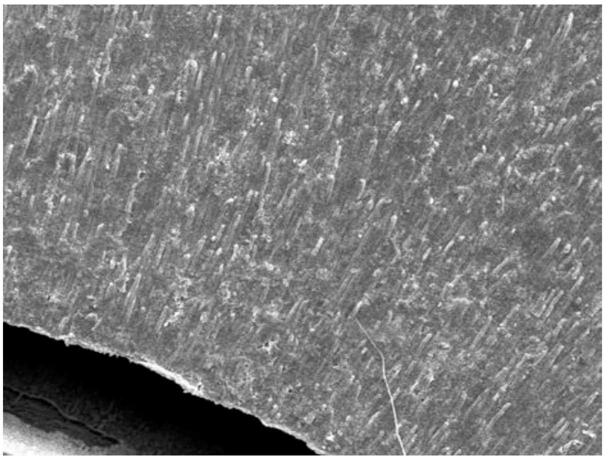
Figures 2A Group 1: short resin tags (G2 Bond) are visible and adhesive failure type (SEM x800).



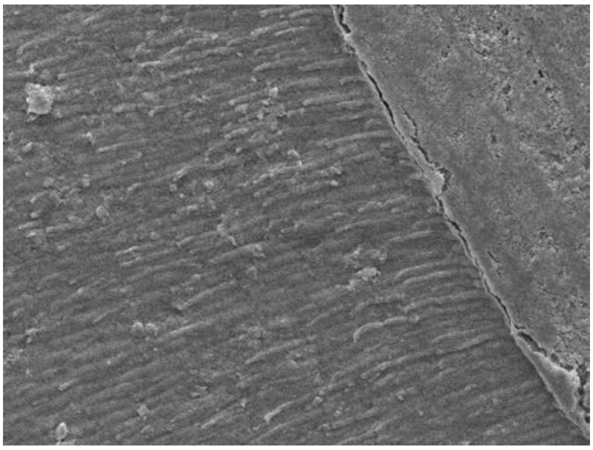
Figures 2B Group 2: no resin tags (G-Premio Bond) are visible and adhesive failure type (SEM x200).



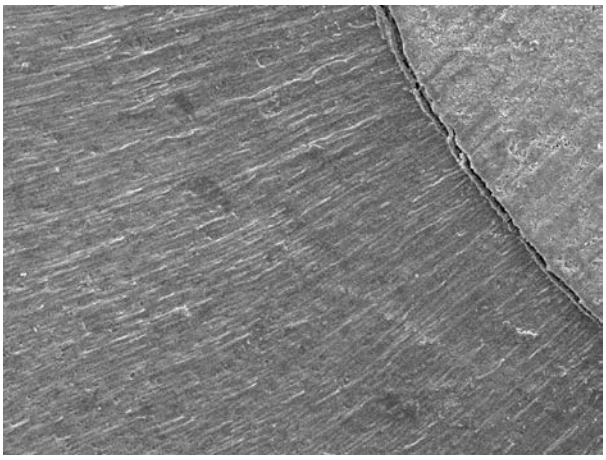
Figures 2C Group 3: resin tags (G2 Bond) formation after ultrasonic activation (SEM x1200).



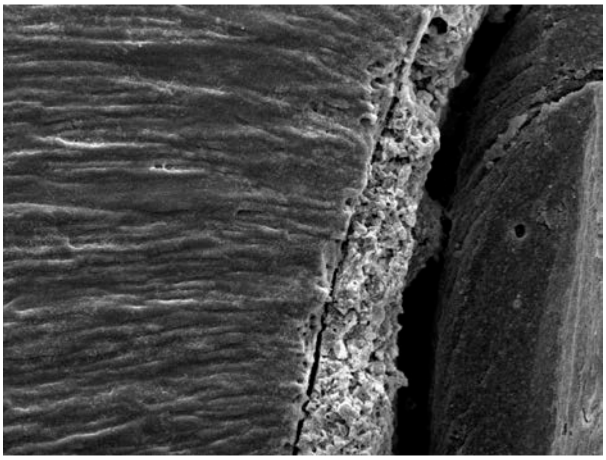
Figures 2D Group 4: Resin tags (G-Premio Bond) after Ultrasonic Activation and adhesive failure (SEM x270).



Figures 2E Group 5: Mixed failure (SEM x500).



Figures 2F Group 6: Resin tags formation (G-Premio Bond) after ultrasonic Activation and adhesive failure (SEM x300).



Figures 2G Group 7: Mixed failure sample; the SEM picture shows the debonding at cement and post interface (SEM x500).

4. Discussion

In this study, EverX Flow showed statistically equal intra-radicular bonding when compared to those of traditional prefabricated fiber post groups. This led to the acceptance of null hypothesis.

Fiber posts, i.e. fiber-reinforced composites of unidirectional glass fibers present an elasticity modulus similar to that of the root dentin, an aspect that might considerably

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reduce the risk of root fractures [25, 26], along with high aesthetic outcomes of the restorative treatment [27]. However, bonding of fiber posts to the root is technique-sensitive and also operator-dependent due to the different required clinical steps in deep root canals; this can be considered as weakness of the clinical procedure [28]. Moreover, the placement of FRC posts often implies extensive removal of the root dentin, which is a major drawback, since tissue preservation is strongly associated with the survival of endodontically treated teeth [29,30]. The resin composite core-built-up material such as Gradia Core when used and luting cement in combination with a prefabricated glass fiber post shows comparable bonding properties but higher material cohesive strength properties that actual resin composite luting cements on the market. In fact, even the four-year follow-up work [31] demonstrated the advantageous properties of the Gradia Core material.

Despite the properties and bonding techniques of more modern resin based materials, the most common type of failure when using fiber posts remains to be debonding of the post at the post-dentin interface [32]. The debonding [33] can be due to several different factors on the dentin and post surface sites: post surface treatments (adhesive application and mode of polymerization), the inability of the cement to reach and polymerize the deeper areas of the root canal, as well as the shape of the root canal [26, 34, 35]; if the post does not fit well, there will be too thick a layer of cement, especially at the coronal level, where air bubbles or voids could be incorporated, predisposing to debonding. Also, transmission of curing light into the root canal via fiber post plays a role in durability of the cementation toward post and dentin with resin composite cements [36-38]. In the case of prefabricated fiber posts, bonding of luting cements is low due to the high cross-link density of the polymer matrix of the post [37].

The use of EverX Flow, a discontinuous glass fiber reinforced resin composite ~~resin~~ as intra-radicular filling and post replacing material permits to eliminate some of the variables which may increase technique sensitives of the current weaknesses with prefabricated fiber posts. Use of injectable composite with short fibers and related increased fracture toughness of the material and simplified handling and operative steps may increase clinical success of the treatment. Attention should be paid to the post-curing adaption of the luting and other resin based materials to the dentin surface. Translucent shade EverX Flow Bulk polymerizes to the depth of 5 mm and the discs of measuring the bonding properties and post-curing adaptation of the composite in the present study were cut in the area of polymerized composite. Root canal of depth of 5 mm with thick infovidually fomed root canal post have shown to provide better load-bearing capacity for the restoration than thinner prefabricated posts with higher post length [39-40].

The application of EverX Flow into the root canal space does not require any use of post- space preparation [41-42]. Therefore, the adaptation to the root canal anatomy, without additional dentin removal, may be of advantage for tissue preservation.

The push-out test is a critical test to measure the axial bond strength of a post-retained restoration bonded to root canal dentine [11]. In this study, EverX Flow tested for intracanal anchorage, achieved statistically similar push-out bond strength values to those of a traditional fiber post system with particulate filler resin composite. This recent material consists of a combination of a resin matrix, discontinuous E glass fibers and inorganic particulate fillers. The resin matrix contains cross-linked monomers, bisphenol-A-glycidyl dimethacrylate (bis-GMA), and triethylene glycol dimethacrylate (TEGDMA). The composition differs from the composition of continuous unidirectional fiber reinforced composite which is used in individually formed fiber posts (everStick Post) which also contains linear polymethyl methacrylate (PMMA) and forms a semi-interpenetrating polymer network (semi-IPN) on curing, which is demonstrated to improve bonding and toughness properties of the composite resin [18]. Formation of semi-IPN bonding is not needed with discontinuous fiber composite of EverX Flow in the root canal application because free radical polymerization of the composite allows simultaneously good bonding the adhesives.

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The reinforcing effect of the fiber fillers having high enough aspect ratio (typically >20) and critical fiber length which relates to the fiber adhesion to the polymer matrix is based on stress transfer from polymer matrix to fibers and individual fibers as a crack stopper to hinder crack growth. Discontinuous and randomly oriented fibers provide an isotropic reinforcing effect, specifically the strength of the material is independent of the fracture load direction and is comparable in all directions [18, 41, 42]. Moreover, an inherently uniform stress distribution to the hard biological tissues has also been documented for EverX Flow, mainly due to fracture toughness values matching those reported for dentin [43]. It is also likely that the discontinuous glass fibers of diameter or 5-6 micrometers could provide micromechanical interlocking to the dentine surface irregularities which could increase adhesive properties in shear stress situation.

This study also evaluated the bond strength to intra-radicular dentin of a two-step self-etch adhesive (G2 Bond Universal) compared to an universal adhesive (G-Premio Bond). The corresponding push-out test showed only a light superiority of G2 Bond Universal.

Two-step self-etch adhesives, which involve applying an additional layer of solvent-free hydrophobic resin, create stronger adhesive layers than one-step self-etch adhesives, which contain volatile solvents, hydrophilic monomers, water [44] for acidic functional monomers dissociation [45].

The one-step universal adhesive G-Premio Bond contains highly volatile acetone evaporates quickly, leaving water behind. Too much remaining water can contribute to incomplete polymerization, culminating in a weak interface and premature bond failure [46, 47]. G2-Bond Universal adhesive is a two-bottle system but has a HEMA-free composition similar to G-Premio Bond [48]. Thanks to its two-bottle strategy and UDMA in the bonding resin, G2-Bond Universal provides a more hydrophobic bond layer [48, 49] which imparts a better shock-absorbing effect against shrinkage stress [50]. The use of two-step adhesive system also leads to lower number of adhesive failures at the bonding interfaces.

In addition to external factors such as irrigants, types of adhesives, endodontic sealers and factors related to dentin, intracanal adhesion depends on the removal of the smear layer and the creation of a hybrid layer between root canal and adhesive resin [51]. The smear layer can be removed using a combination of chelating agents and NaOCl [52, 53]. As a complement to various irrigant solutions, ultrasound contributes to the elimination of the smear layer [54, 55]. The microscopic analysis showed more even adaptation and possibly even extended resin tags on the root surface in the ultrasonic irrigant activated groups. Also, the push-out test revealed that irrigant activation affects the bond strength to intra-radicular dentin.

The combination of ultrasonic activation of EDTA and NaOCl, G2 Bond Universal and EverX Flow showed the highest bond strength to intraradicular dentin, a deep penetration of resin tags in to the tubules and more favorable type of failure.

5. Conclusions

Within the limitations of this in vitro study, it may be concluded that EverX Flow, a discontinuous glass fiber reinforced composite, used for intracanal anchorage in the post-endodontic reconstruction, achieved similar push-out retentive strengths to those of traditional fiber posts. EverX Flow in combination with a two-step adhesive system and ultrasonic irrigation represents a viable and operatively simpler alternative to traditional fiber post adhesion within the 5 mm light curing depth.

Disclosure

Author PV consults GC Corporation in RD and training.

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