Saudi Dental Journal (2021) 33, 22–26

King Saud University

Saudi Dental Journal

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ORIGINAL ARTICLE

Push-out bond strength of fiberglass posts cemented with adhesive and self-adhesive resin cements according to the root canal surface

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Received 13 September 2019; revised 18 November 2019; accepted 21 November 2019
Available online 28 November 2019

KEYWORD

Bond strength;
Resin cement;
Self-adhesive;
Fiberglass post;
Dentin surface

Abstract *Objective:* Evaluating the bond strength of fiberglass posts cemented with different resin cements. Materials and Methods: Seventy freshly extracted roots of healthy human canines were endodontically treated and prepared to receive fiberglass posts. The roots were randomly divided into seven groups: (G1) RelyX ARC, (G2) Enforce, (G3) BisCem, (G4) Duo-Link, (G5) Cement Post, (G6) Variolink II, and (G7) RelyX U200. After post cementation, the specimens were sectioned perpendicularly to the root axis using a high-speed diamond disc, totaling 340 specimens. The strength values obtained in the push-out test were submitted to two-factor ANOVA and Tukey test ($p = 0.05$). Results: The root thirds ($p = 0.001$) and the type of cement ($p = 0.001$) influenced the bond strength values. The relation between these two factors was also significant ($p = 0.011$). Conclusions: The bond strength of self-adhesive resin cements was significantly higher as compared to other cements. Besides the cervical third in roots cemented with conventional cements types presented the highest bond strength values ($p < 0.05$).

1. Introduction

Restoration of endodontically treated teeth with extensive coronal destruction has been widely studied (Brignardello-Petersen, 2017). Due to the tooth structure loss, rehabilitation of these teeth requires the use of intraradicular retainers to support the restoration or the crown, making them functional in the stomatognathic system.

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Peer review under responsibility of King Saud University.

Production and hosting by Elsevier

https://doi.org/10.1016/j.sdentj.2019.11.009
1013-9052

New techniques and materials have been developed, and with them, new alternatives to endodontically teeth restoration (Brignardello-Petersen, 2017; Pereira et al., 2015; Cloet et al., 2017). Recently, materials choice for intraradicular cores of endodontically treated teeth has changed from the exclusive use of very rigid materials to materials with mechanical characteristics close to those of the dentin, reducing the risk of radicular fracture (Türker et al., 2015; Sarkis-Onofre et al., 2014).

Examples of these materials are the fiberglass posts, which have the advantage of requiring low quantity of intraradicular wear to accommodate these posts. They also have an elastic modulus near to that of the dentin, and they may present better aesthetic properties because they are translucent (Pereira et al., 2015; Paolone et al., 2013).

Resin cements are widely used to cement fixed prosthesis, inlays, onlays and intraradicular posts. However, bond strength is significantly influenced by the technique used for each type of cementation (Werle et al., 2015; Masarwa et al., 2016). Nevertheless, clinical research has demonstrated high success scores with fiberglass posts and composite resin (Amaral et al., 2015; Barfeie et al., 2015; Parisi et al., 2015). Displacement of post is reported in several works as the major cause of failures, and it may be related to the cement deterioration by functional loads due to masticatory efforts (Bhagat et al., 2017; Li et al., 2014; Abdulrazzak et al., 2014), as well as hydrolytic degradation between the bonded dentin and resin cements over time (Reis et al., 2015).

Nowadays, several types of cements are launched in the market, such as dual-cured resin cements, which are indicated for cementation within root canals because of curing light difficulty to reach the canal deep areas. Other examples of new materials include adhesives and cements which do not need dentin acid etching. The lack of clinical experience in the long run indicates that laboratorial research to broaden knowledge and improve the behavior of these new materials are necessary.

Based on this information, the aim of this research was to evaluate the bond strength of adhesive and self-adhesives resin cements used to cement intraradicular glass fiber posts in different thirds of the root canal. The null hypothesis tested was that different resin cements would not influence the bond strength of fiberglass posts regardless the root canal surface.

2. Materials and methods

Seventy freshly extracted caries-free human maxillary canines with similar dimensions and anatomic structure were selected and stored in 0.9% physiologic saline with 1% thymol at room temperature. The root lengths (15 mm) and bucco-lingual diameters (6 mm) were measured at cementum-enamel junction with digital calipers (Mitutoyo, USA). This sample size was calculated using means and standard deviations. The teeth were examined under x4 magnification microscope (N107, Coleman, Brazil) to remove periodontal tissue remnants, and periapical radiographs were obtained to verify the absence of fractures and internal root resorption. Approval was obtained from the local ethical committee at the University of Southern Santa Catarina.

Tooth crowns were removed (IsoMet 4000, Buehler, USA) and endodontic instrumentation was performed manually with flexible stainless-steel K-files (Mani, Japan), using the balance force technique (Roane et al., 1985) towards the apex until the working length was achieved. Root canal of each tooth was instrumented with manual K-files (Dentsply Maillefer, Switzerland), using a step-back technique. From the initial apical instrument, canals were enlarged to an apical size of a #30 K-file, with working length in 1 mm short of the apex. Next, scaling up to a #55 file was performed. Between each change of instrument, irrigation was performed using 1% sodium hypochlorite solution and 17% ethylenediaminetetraacetic acid alternately (EDTA solution). At the end of the instrumentation, root canals were washed with saline solution (0.9% NaCl) and dried with absorbent paper points (Tanari, Brazil). Then, root canals were obturated by lateral condensation technique, using master gutta-percha cones #35 (Tanari, Brazil) and sealed with epoxy resin and calcium hydroxide paste (Sealer 26, Dentsply Maillefer, Switzerland). Once the endodontic treatment was completed, the roots were stored in distilled water at 37 °C for at least one week. Filling material was removed by heated Rhein points and the canals were enlarged with Largo drills number 2, 3 and 4 (Mani, Japan), at low rotation speed until 10 mm deep, keeping at least 3 mm of filling material remaining in the apex. Then, canals were irrigated with sodium hypochlorite, followed by distilled water and dried with absorbent paper cones. After the filling removal procedure, the roots were randomly divided into seven groups: (G1) RelyX™ ARC (3 M ESPE, USA), (G2) Enforce (Dentsply, Switzerland), (3) BisCem™ (Bisco, USA), (G4) Duo-Link™ (Bisco, USA), (G5) Cement Post (Angelus, Brazil), (G6) Variolink II (Ivoclar Vivadent, Liechtenstein) and (G7) RelyX™ U200 (3 M ESPE, USA). Roots were placed and adapted in a metallic device according to their diameter. Next, metallic device was filled with water, remaining only the cervical third exposed. Prior to cementing, #2 fiberglass posts (Reforpost, Angelus) were inserted into the root canals already prepared to check their adaptation. After, posts were cleaned with 95% ethanol solution, dried-off using air jets, and the silane coupling agent was applied according to the manufacturer instructions (GC, USA). In groups 1, 2, 4, 5 and 6, root dentin acid etching was performed using 35% phosphoric acid for 15 s (Ultra-Etch, Ultradent), followed by washing for 30 s and dried-off with air jets and absorbent paper cones. Next, etch-and-rinse adhesive system (Scotchbond Multi-Purpose, 3 M ESPE) was applied using a microbrush and excessive adhesive was removed with an absorbent paper cone. In groups 3 and 7, neither acid etching nor adhesive application are recommended by the manufacturer. Resin cements were prepared, and the fiberglass posts were cemented following the manufacturer instructions. The post was also covered with cement, and immediately inserted into the root canal. Then, excessive cement was removed, and the whole set was polymerized using a 1400 mW/cm^2 power light-curing unit (Valo, Ultradent) for 20 s. Finally, the acid etching was performed and the adhesive (Scotchbond Multi-Purpose) was applied in the coronal portion of specimens, and filling cores were prepared with hybrid composite resin (Charisma, Heraeus Kulzer). In order to simulate moist conditions in the oral environment, all cementations occurred in a humid environment.

All specimens undergo 250,000 mechanical cycling cycles with a load of 30 N on the palatal surface, 3 mm below the incisal edge, with 2.6 Hz frequency at 45°angle from the long axis of the tooth, and thermocycled in distilled water (6000 cycles; 5C/55C, 2-minute dwell time). Specimens were storage at 37C artificial saliva during the entire cycling stage.

To perform the push-out test, cervical, medium and apical thirds were sectioned perpendicularly to the root axis using a with a low-speed diamond wafering blade under water irrigation (IsoMet 5000, Buehler). Therefore, 340 slices of approximately 1.3 mm each were obtained. Subsequently, specimens were stored in distilled water at 37 °C in containers for 12 h, which prevented light from passing through. After cutting procedures, the specimens were placed on a metal base made of stainless steel, having a central hole of 2 mm in diameter. Next, the loading was applied on the post, on the root slice apical face using a tip with 1.0 mm in diameter and coupled to a universal testing machine (Emic, Brazil) at 0.1 mm/min, until the post was displaced.

The bond strength to the post displacement (σ) (MPa) was obtained by the formula $\sigma = C/A$, where C represents the loading at the specimen failure time (N), and A corresponds to the area of bonded interface (mm^2). To determine the area (A), the following formula was used to calculate the lateral area of a circular cone of parallel bases: $A = \pi(R + r)[(h)^2 - + (R - r)^2]0.5$, where $\pi = 3.14$, r = apical radius of fiberglass post (mm), R = coronal radius of fiberglass post (mm), and h = specimen thickness (1 mm). The two-way ANOVA test was used to determine the effects of cement type and root thirds, and the interaction between these two factors. The Tukey test was used to compare the groups. The significance level was set at $\alpha = 0.05$.

3. Results

Mean values and standard deviation (SD) of bond strength in the different thirds of the experimental groups are shown in Table 1. Results of ANOVA test revealed statistically significant differences regarding the cement type ($p = 0.001$) and the root third ($p = 0.001$). The relation between these two factors was also significant ($p = 0.011$).

Tukey test showed that bond strengths in self-adhesive resin cements groups (BisCem and RelyX U200) were significantly higher, when compared to the other groups ($p < 0.001$). In addition, the cervical third showed the highest bond strength values in the roots cemented with conventional cements, then statistically different for Duo-Link cement ($p < 0.05$) (Table 1).

4. Discussion

Null hypothesis that different resin cements do not influence the bond strength of fiberglass posts regardless of root canal surface was rejected. According to the results from this study, bond strength of self-adhesive cements was significantly higher when compared to conventional cements. This result may be explained by the quantity of diluent monomers, which are different between the two materials (Karkera et al., 2016). Inorganic particle amount by weight in self-adhesive cements is higher than in conventional cements, which reduces the cement polymerization shrinkage and improves stability. These results corroborate those reported by Aleisa et al. (2013) and Silveira-Pedrosa et al. (2016), who have claimed that self-adhesive cement had better results by comparing the bond strength rates with those presented by cements of acid etching or self-etching.

Contrastingly, Calixto et al. (2012) have shown that bond strength of resin cements used with etch-and-rinse and self-etch adhesive systems seem to be adequate for glass fiber post cementation. The authors have indicated the use of phosphoric acid separately as more effective to remove the smear layer from the canal walls, when compared to luting with methacrylate phosphoric esters. However, highlight that acid etching removes both the smear layer and the organic content of dentin is important (Oshima et al., 2015), because it may damage the bond between cement and dentin, and reduce the bond strength.

Cervical thirds cemented with conventional cements presented higher bond strength values when compared to the other thirds. It might be explained because the number of dentinal tubules is higher than in the roots cervical portion of roots, decreasing gradually towards the apical direction (Arora et al., 2017). Access and procedures such as acid etching, drying, adhesive application and curing required by conventional cements are more complicated in the apical region of root. It explains the difficulty to achieve adequate adhesive strength in this region.

The apical portion of roots cemented with self-adhesive cements presented higher bond strength as compared to the other thirds. This may indicate that the depth and density of dentinal tubules are not critical factors for these cements. Regarding the dentin tubules, Rezende et al. (2016) reported that density is high in cervical region and decreases gradually towards the apical direction. The findings may prove that bond strength values in apical thirds were higher, when compared to the other root thirds. Another cause could be the adhesive

Table 1 Mean strength values (MPa) of each type of cement followed by their respective standard deviation (SD).

Groups	Cervical third	Middle third	Apical third	Total
RelyX ARC	$8.41 \pm 8.02^{b,c,d}$	$4.77 \pm 4.10^{a,b}$	$0.93 \pm 1.15^{a,b}$	5.48 ± 6.22^{B}
Enforce	$6.97 \pm 5.61^{a,b,c}$	$4.47 \pm 2.73^{a,b}$	$2.11 \pm 1.52^{a,b}$	4.71 ± 4.19^{AB}
BISCEM	17.50 ± 5.10^{f}	$15.39 \pm 5.10^{e,f}$	17.48 ± 4.04^{f}	16.71 ± 4.83^{D}
DUOLINK	$11.52 \pm 7.35^{c,d,e}$	$6.09 \pm 3.65^{a,b}$	$3.10 \pm 2.06^{a,b}$	7.18 ± 5.98^{B}
Cement Post	$3.15 \pm 1.95^{a,b}$	$2.04 \pm 2.00^{a,b}$	0.70 ± 0.56^{a}	2.13 ± 1.96^{A}
Variolink II	$4.61 \pm 4.03^{a,b}$	$1.59 \pm 1.50^{a,b}$	$1.04 \pm 0.82^{a,b}$	2.46 ± 2.97^{A}
RelyX U200	$13.58 \pm 3.79^{d,e,f}$	$14.25 \pm 7.99^{e,f}$	$12.53 \pm 2.20^{c,d,e,f}$	13.54 ± 5.47^{C}

Different letters indicate statistical differences. Equal capital letters in the same column indicate statistical differences between the total values of bond strength.

technique used in the cementation of posts, which requires some criteria, such as the time of etching, cleaning of the canal, adhesive application, and the cement choice. An excessive acid etching demineralizes the dentin to an extent that prevents the adhesive to penetrate, generating areas of low bond strength. Besides, any residue remaining within the canal, such as acid, endodontic cement, gutta-percha, among others, may affect the post retention within the root canal (Kaya et al., 2015; Daleprane et al., 2016; Daneshkazemi et al., 2015).

In this study, a metallic device was used to simulate the humidity conditions in the oral cavity. The aim at simulation was to allow a better assessment and understanding the adhesive systems performance and their degradation mechanisms (Almohareb, 2017; Pereira et al., 2018; Wagner et al., 2017).

Bond strength can be determined through several techniques, although they believe that push-out test provides the best estimate of actual adhesive strength (Almohareb, 2017). Push-out test allows failure to occur parallel to the post-cement-dentin interface, similar the clinical condition. Thus, the push-out test was the method selected to evaluate the tensile bond strength to avoid fiberglass post displacement. Self-adhesive resin cements represent a reliable alternative for intraradicular cementation of posts, given that they are less complex and sensitive to manipulate. However, although in vitro studies show that these cements present good results in the push-out test, further clinical studies are required to verify this finding.

5. Conclusion

Self-adhesive resin cements presented better bond strength when compared to other conventional luting cements. Conventional cements exhibited good adhesive strength in the cervical region.

Declaration of Competing Interest

The authors declare that there is no conflict of interest regarding the publication of this paper and received no financial support for the research, authorship, and/or publication of this article.

References

Abdulrazzak, S.S., Sulaiman, E., Atiya, B.K., Jamaludin, M., 2014. Effect of ferrule height and glass fibre post length on fracture resistance and failure mode of endodontically treated teeth. Aust. Endod. J. 40, 81–86.

Aleisa, K., Al-Dwairi, Z.N., Alghabban, R., Goodacre, C.J., 2013. Effect of luting agents on the tensile bond strength of glass fiber posts: an in vitro study. J. Prosthet. Dent. 110, 216–222.

Almohareb, T., 2017. Sealing ability of esthetic post and core systems. J. Contemp. Dent. Pract. 18, 627–632.

Amaral, M., Coppo, P.P., Rosalem, C.G., Suaid, F.F., Guerra, S.M., 2015. A 3-year retrospective evaluation of the clinical performance of fiber posts. Braz. Dent. J. 26, 619–623.

Arora, J., Talwar, I., Sahni, D., Rattan, V., 2017. Morphology and age-related changes in calcospherites of human teeth: an ultrastructural study. Ann. Hum. Biol. 44, 349–356.

Barfeie, A., Thomas, M.B., Watts, A., Rees, J., 2015. Failure mechanisms of fibre posts: a literature review. Eur. J. Prosthodont. Restor. Dent. 23, 115–127.

Bhagat, A., Mittal, L., Mogla, S., Kaur, T., Dheeraj, M., Marwah, G., 2017. Impact of root dentin thickness on the in vitro compressive strength of teeth treated with recent post and core systems. J. Contemp. Dent. Pract. 18, 1065–1070.

Brignardello-Petersen, R., 2017. Post-retained single crowns placed in endodontically treated teeth with more than 50% of dental tissue remaining probably have a high survival after 7 years. J. Am. Dent. Assoc. 148, e204.

Calixto, L.R., Bandéca, M.C., Clavijo, V., Andrade, M.F., Vaz, L.G., Campos, E.A., 2012. Effect of resin cement system and root region on the push-out bond strength of a translucent fiber post. Oper. Dent. 37, 80–86.

Cloet, E., Debels, E., Naert, I., 2017. Controlled clinical trial on the outcome of glass fiber composite cores versus wrought posts and cast cores for the restoration of endodontically treated teeth: a 5-year follow-up study. Int. J. Prosthodont. 30, 71–79.

da Silveira-Pedrosa, D.M., Martins, L.R., Sinhoreti, M.A., Correr-Sobrinho, L., Sousa-Neto, M.D., Junior, C.E., de F Filho, P., de Carvalho, J.R., 2016. Push-out bond strength of glass fiber posts cemented in weakened roots with different luting agents. J. Contemp. Dent. Pract. 17, 119–124.

Daleprane, B., Pereira, C.N., Bueno, A.C., Ferreira, R.C., Moreira, A. N., Magalhães, C.S., 2016. Bond strength of fiber posts to the root canal: Effects of anatomic root levels and resin cements. J. Prosthet. Dent. 116, 416–424.

Daneshkazemi, A., Davari, A., Akbari, M.J., Davoudi, A., Badrian, H., 2015. Effects of thermal and mechanical load cycling on the dentin microtensile bond strength of single bond-2. J. Int. Oral. Health. 7, 9–13.

Karkera, R., Raj, A.P., Isaac, L., Mustafa, M., Reddy, R.N., Thomas, M., 2016. Comparison of the solubility of conventional luting cements with that of the polyacid modified composite luting cement and resin-modified glass ionomer cement. J. Contemp. Dent. Pract. 17, 1016–1021.

Kaya, S., Yiğit Özer, S., Adigüzel, Ö., Oruçoğlu, H., Değer, Y., Tümen, E.C., Uysal, İ., 2015. Comparison of apical microleakage of dual-curing resin cements with fluid-filtration and dye extraction techniques. Med. Sci. Monit. 21, 937–944.

Li, X.J., Zhao, S.J., Niu, L.N., Tay, F.R., Jiao, K., Gao, Y., Chen, J. H., 2014. Effect of luting cement and thermomechanical loading on retention of glass fibre posts in root canals. J. Dent. 42, 75–83.

Masarwa, N., Mohamed, A., Abou-Rabii, I., Abu Zaghlan, R., Steier, L., 2016. Longevity of self-etch dentin bonding adhesives compared to etch-and-rinse dentin bonding adhesives: a systematic review. J. Evid. Based. Dent. Pract. 16, 96–106.

Oshima, M., Hamba, H., Sadr, A., Nikaido, T., Tagami, J., 2015. Effect of polymer-based desensitizer with sodium fluoride on prevention of root dentin demineralization. Am. J. Dent. 28, 123–127.

Paolone, G., Saracinelli, M., Devoto, W., Putignano, A., 2013. Esthetic direct restorations in endodontically treated anterior teeth. Eur. J. Esthet. Dent. 8, 44–67.

Parisi, C., Valandro, L.F., Ciocca, L., Gatto, M.R., Baldissara, P., 2015. Clinical outcomes and success rates of quartz fiber post restorations: a retrospective study. J. Prosthet. Dent. 114, 367–372.

Pereira, G.K.R., Lançanova, M., Wandscher, V.F., Kaizer, O.B., Limberger, I., Özcan, M., Valandro, L.F., 2015. Fiber-matrix integrity, micromorphology and flexural strength of glass fiber posts: evaluation of the impact of rotary instruments. J. Mech. Behav. Biomed. Mater. 48, 192–199.

Pereira, J.R., Pamato, S., Vargas, M., Junior, N.F., 2018. State of the art of dental adhesive systems. Curr. Drug. Deliv. 15, 610–619.

Reis, A., Martins, G.C., de Paula, E.A., Sanchez, A.D., Loguercio, A. D., 2015. Alternative aging solutions to accelerate resin-dentin bond degradation. J. Adhes. Dent. 17, 321–328.

Rezende, E.C., Gomes, G.M., Szesz, A.L., da Silveira Bueno, C.E., Reis, A., Loguercio, A.D., 2016. Effects of dentin moisture on cementation of fiber posts to root canals. J. Adhes. Dent. 18, 29–34.

Roane, J.B., Sabala, C.L., Duncanson Jr, M.G., 1985. The ''balance force'' concept for instrumentation of curved canals. J. Endod. 11, 203–211.

Sarkis-Onofre, R., Jacinto, R.C., Boscato, N., Cenci, M.S., Pereira-Cenci, T., 2014. Cast metal vs. glass fibre posts: a randomized controlled trial with up to 3 years of follow up. J. Dent. 42, 582–587.

Türker, S.A., Özçelik, B., Yilmaz, Z., 2015. Evaluation of the bond strength and fracture resistance of different post systems. J. Contemp. Dent. Pract. 16, 788–793.

Wagner, M.H., da Rosa, R.A., de Figueiredo, J.A.P., Duarte, M.A.H., Pereira, J.R., Só, M.V.R., 2017. Final irrigation protocols may affect intraradicular dentin ultrastructure. Clin. Oral Investig. 21, 2173–2182.

Werle, S.B., Steglich, A., Soares, F.Z., Rocha, R.O., 2015. Effect of prolonged air drying on the bond strength of adhesive systems to dentin. Gen. Dent. 63, 68–72.