The Saudi Dental Journal 36 (2024) 574–578

Contents lists available at ScienceDirect

The Saudi Dental Journal

journal homepage: www.ksu.edu.sa
www.sciencedirect.com

Original Article

Effect of reapplication on pull-out bond strength of fibre post to root dentin: An in vitro study

Nuray İskefli [a], Elif Yeğin [a,*], Güzide Pelin Sezgin [b], Sema Sönmez Kaplan [b], Tuna Kaplan [b]

[a] İstanbul Medeniyet University, Faculty of Dentistry, Department of Prosthodontics, Istanbul, Turkey
[b] Biruni University, Faculty of Dentistry, Department of Endodontics, Istanbul, Turkey

ARTICLE INFO

Keywords:
Bond strength
Fibre post
Post removal
Pull-out test
Re-applied post

ABSTRACT

Purpose: Post removal may be necessary for many reasons and is inevitable after the re-application of a dental post. The present study investigated the bond strength between root dentin and a re-applied fibre-reinforced composite (FRC) post by a pull-out test.
Materials and methods: After root canal treatments of 30 extracted human maxillary canine teeth, post spaces were prepared (10 mm), and FRC posts (Hi-Rem Post; Overfibres, İmola, Italy) were luted with self-adhesive resin cement. The samples were than randomly divided into test and control groups (n = 15 in each). The FRC posts were removed in the test group, and new posts were cemented. The pull-out test (1 mm/minute speed) was used to measure the bond strength. Failure types were determined using a stereomicroscope. Mann-Whitney U, chi-square and Fisher-Freeman-Halton exact tests were used for statistical analysis.
Results: The bond strength values of the test (119.5 ± 36.86 N) and control (115.55 ± 55.44 N) groups did not differ significantly (p >.05). In terms of the percentage of failure types, there was a significant difference only in the test group between the mixed failure type and the other failure types (p <.05).
Conclusions: The re-application of FRC post did not seem to affect the bond strength. The distribution of failure types was similar between the control and test groups.

1. Introduction

Teeth with insufficient structure can be restored using different dental posts, such as metals, ceramics or fibre-reinforced composites (FRCs) (Goracci and Ferrari, 2011). The risk of vertical root fracture is reduced with FRC posts that have a similar elastic modulus to that of with dentin (Baba et al., 2009). As these posts are tooth coloured, they are usually favoured over other posts for aesthetic reasons (Goracci and Ferrari, 2011).

Debonding between dentin and the adhesive cement is the most common failure type in restorations with FRC posts (Cagidiaco et al., 2008). The durability of bond strength between the post surface, dentin and adhesive cement determines the prognosis of such restorations. The bond strength affects the force distribution along the root, decreases the risk of root fracture and strengthens the remaining tooth structure (Goracci and Ferrari, 2011).

Removal of a post may be necessary due to root canal re-treatment or improvements in prosthetic design with mechanical or aesthetic reasons. Various methods and tools have been suggested for removing different types of posts, including ultrasonic instruments, specific removal kits and lasers (Anderson et al., 2007; Arukaslan and Aydemir, 2019; Cho et al., 2022). However, all these methods are challenging and time consuming. Furthermore, the use of an endodontic microscope and operator experience are critical factors in the success of these procedures. Extreme care must be taken not to damage the remaining tooth structure and the root canal (Maia et al., 2019).

Recently, a glass fibre post (Hi-Rem Post; Overfibres, İmola, Italy) containing blue coloured soft polymer micro-fibre in the centre has been marketed to facilitate FRC post removal. According to the literature, the removal procedure is easy and non-invasive (Scotti et al., 2013).

In the literature, there have been studies which evaluate the influence of different factors such as surface treatment methods, the type of cement, cement film thickness and canal irrigation solutions on the bond strength between FRC post and dentin (Aleisa et al., 2021; Alkahtany,2022; Cecchin et al., 2016; Durski et al., 2016; Pereira et al., 2014; Rezaei-Soufi et al., 2019). Since, there have been no studies on a re-applied FRC post; the aim of the current study was to evaluate the bond strength between the root dentin and a re-applied FRC post by a

* Corresponding author at: İstanbul Medeniyet University, Faculty of Dentistry, Department of Prosthodontics, Istanbul, Turkey.
E-mail address: dtelifyegin@gmail.com (E. Yeğin).

https://doi.org/10.1016/j.sdentj.2024.01.011
Received 16 August 2023; Received in revised form 11 January 2024; Accepted 23 January 2024
Available online 26 January 2024
1013-9052/© 2024 THE AUTHORS. Published by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

pull-out test. The null hypotheses of the study were as follows:

(1) The bond strength would not be affected by the re-application of the FRC post.
(2) There would be no difference in the distribution of failure types in the control and re-applied test groups.

2. Materials and methods

Ethics committee approval was obtained from Biruni University (Date: 02.01.2020, Protocol No: 2020/36-13). Power analysis (G*Power; Heinrich Heine University, Germany) was used to calculate the sample size based on a previous study (Topçuoğlu et al., 2018). The power calculation (power of 80 %, significance level of 0.05 and effect size of 0.85) revealed that 12 samples were required in each group. In the present study, there were 15 samples in each group.

Maxillary human canine non-carious single-rooted teeth with a completed apex were used in the present study. The teeth were immersed in a 0.12 % chloramine solution for approximately 4 months until the experiment. All teeth were decoronated using a diamond disc 1 mm above the cementoenamel junction to obtain standardized roots of 15 mm in length.

2.1. Root canal treatment

The root canals' preparation was performed with an endomotor (X-Smart Plus; Dentsply Maillefer, Switzerland) and ProTaper Next nickel-titanium files (Dentsply Maillefer, Switzerland) up to the size of X3 (300 rpm, 2 N/cm, size 30, 0.06 taper). At biomechanical preparation, 2 ml of 2.5 % NaOCl was applied to the root canals between each file. 17 % EDTA was used for the final irrigation, and saline solution was then administered to neutralize all the residues. The cold lateral condensation method with root canal sealer (AH Plus; Dentsply Maillefer, Switzerland) and gutta percha was used for obturation. The samples were stored in a humid medium for 1 week after restored with a temporary material.

2.2. FRC post insertion

The post space was prepared using a specific drill according to the manufacturer's advice (depth of 10 mm) (Durski et al., 2016; Pereira et al., 2014). Canal flushing was then performed with 1 % NaOCl and saline solution. Post size #2 (Hi Rem endodontic post; Overfibres, Imola, Italy) was used in all samples. After cleaning post spaces with 70 % ethanol (60 s), they were washed with distilled water and air dried. The same manufacturer's self-adhesive resin cement (Overcem SA;Overfibres, Imola, Italy) was used for the cementation. The FRC post was inserted in the post space by finger pressure and the remaining cement was cured for 40 s at a light intensity of 600 nmW/cm^2 (XL 3000; 3 M ESPE, St. Paul, MN, USA) after the removal of excess resin cement. Samples were kept in sterile saline for 1 week and then divided into two groups randomly: control ($n = 15$) and test ($n = 15$). The control group was directly subjected to the pull-out test. In the other group, the test was performed after reapplication.

2.3. FRC post removal

In the test group, the macro-fibre in the centre of the post was removed using a 25/0.04 ProFile drill (Dentsply Maillefer, Switzerland) after cutting the outside part of the FRC post. The post was then ground out using a Largo drill (Dentsply Maillefer, Switzerland). An ultrasonic tip (SonicFlex Endo; KaVo, Biberach, Germany) was used to remove other debris and remaining cement. The removal process was easy due to the macro-fibre core in the centre of the post, and there was no post fracture during removal process. The FRC posts were then re-applied in the same manner as in the first application.

2.4. Pull-out testing

After completion of the fibre post application, each sample was embedded in an acrylic resin block (Imicryl;Konya, Turkey).

The pull-out tests were performed by an MTS 322 universal testing machine (MTS System Corporation, USA;crosshead speed of 1 mm/min; Fig. 1). The maximum failure load was recorded in Newton (N).

The dislodged posts were visually inspected with a stereomicroscope (Olympus, Tokyo, Japan) at 10 × magnification to evaluate the failure type. Three failure types were defined: adhesive, cohesive and mixed. Adhesive referred to fracture between the cement layer and root canal dentin (adhesive C-D) or between the cement layer and post (adhesive C-P), cohesive referred to fracture within the dentin or post, and mixed referred to a combination of cohesive and adhesive fracture (Rezaei-Soufi et al., 2019).

2.5. Statistical analysis

IBM SPSS Statistics 22 software (Chicago, IL, USA) was used for statistical analysis. Since the Kolmogorov–Smirnov normality test was indicated a non-normal distribution, the Mann-Whitney *U* test was used to compare the bond strength values. For the comparison of the failure types, the Fisher-Freeman-Halton exact test and chi-square tests were used. The significance level was 0.05.

3. Results

The results of the Mann-Whitney *U* test were presented on Table 1. The mean bond strength values of the two groups did not differ significantly ($p = 0.419$, $p > .05$). The Fisher-Freeman-Halton exact and chi-square test results are presented in Table 2. Although the percentage of failure types did not show a statistically significant difference between both groups, there was a statistical difference between only the mixed type (60 %) and the other failure types within the test group ($p = 0.016$, $p < .05$) (Table 2). Adhesive failure was higher in the control group, mixed and cohesive failure were higher in the test group. For the cohesive failure type, one post fracture occurred in the test group, the rests occurred in the dentin surface.

4. Discussion

Debonding between radicular dentin and the post is the most common failure of post-core restorations (Aleisa et al., 2021; Scotti et al., 2013). Besides that, periapical lesions or fibre post fracture require removal of the post (Maia et al., 2022; Scotti et al., 2013). Numerous in vitro studies have investigated the effects of several factors on the bond strength of FRC posts to root dentin (Aleisa et al., 2021; Macedo et al., 2013; Macedo et al., 2010; Sarraf et al., 2019). However, there are no studies on the effect of re-application of FRC post. Therefore, the purpose of the present study was to determine the effect of re-application of FRC posts on bond strength and failure types. The bond strength values were not reduced with the re-application of the FRC post (test group:119.55 N; control group:115.55 N), and distribution of failure types showed no difference between the two groups. Thus, null hypotheses were accepted.

Since FRC post removal is difficult and may cause complications (Liu et al., 2021; Maia et al.,2022), a fibre post (Hi-Rem), including a soft blue polymer macro-fibre that can be removed in a more quickly and safer mode, has been marketed ("Manufacturer's instructions of the post"). Scotti et al. (2013) compared the removal of Hi-Rem Prosthetic Posts (Overfibres, Imola, Italy) and D.T. Light-Posts (RTD, France). They concluded that the removal time was significantly reduced with the use of Hi-Rem post and that the operator's experience did not affect it. This was confirmed by the present study, as the removal procedure was practical and quick.

Self-adhesive resin cements were developed for overcoming the

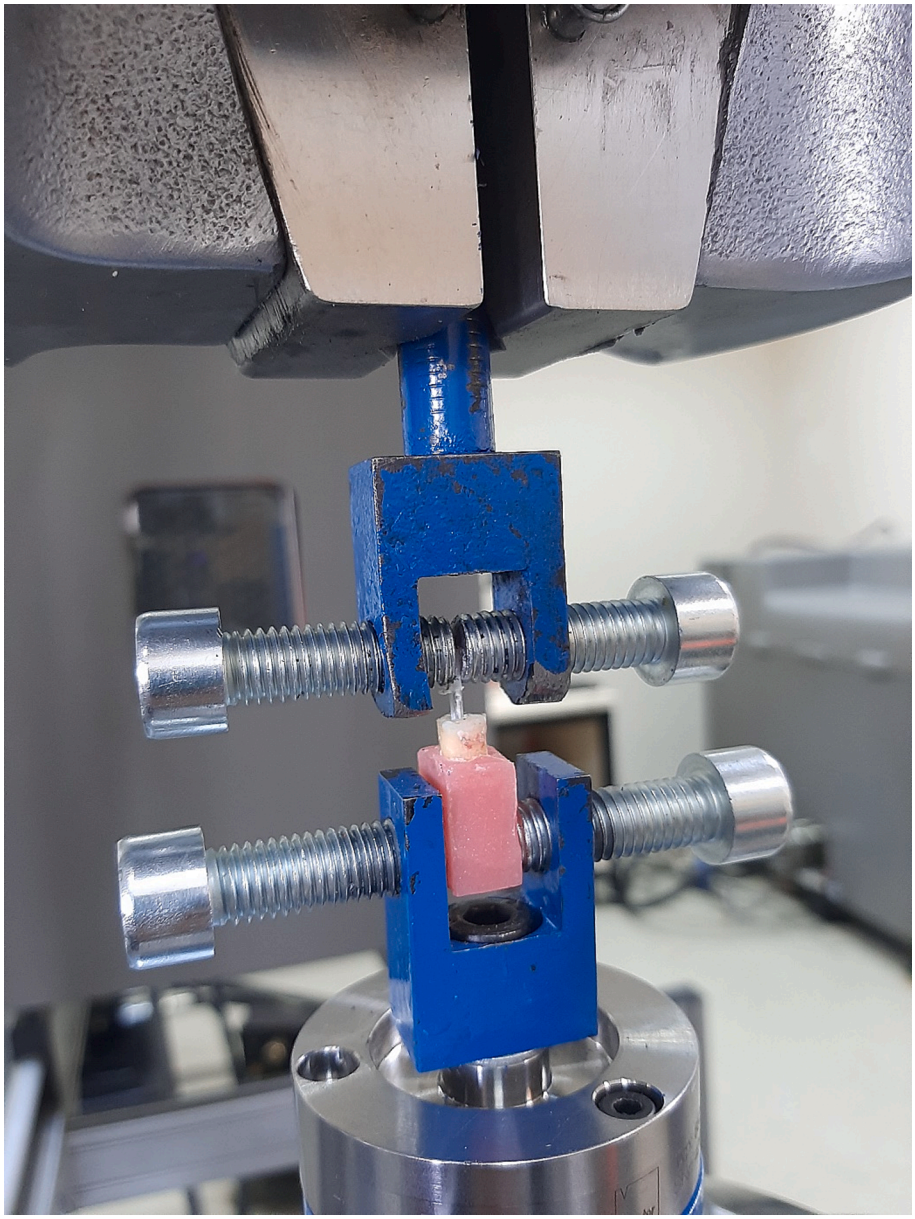


Fig. 1. Pull-out test design.

Table 1
Mean bond strength values (N).

	Mean ± SD	p
Control (n = 12)	115.55 ± 55.44[a]	0.419
Test (n = 12)	119.5 ± 36.86[a]	

Mann Whitney U Test.

Table 2
The percentage of failure types.

Failure type	Control (n = 12) n (%)	Test (n = 12) n (%)	[1]p
Adhesive C-P	4 (%26.7)[a]	2 (%13.3)[a]	0.550
Adhesive C-D	3 (%20)[a]	1 (%6.7)[a]	
Cohesive	2 (%13.3)[a]	3 (%20)[a]	
Mix	6 (%40)[a]	9 (%60)[ab]	
[2]p	0.506	0.016	

[1] Fisher Freeman Halton Exact Test.
[2] One sample chi-square test. (Adhesive C-P: Adhesive fracture between the cement layer and root canal dentin, Adhesive C-D: Adhesive fracture between the cement layer and post). *Different superscript letters define the statistical differences.

complexity and technique sensitivity of multistep systems. These cements require just a single-step procedure and no pre-treatment on application sites (Durski et al., 2016; Macedo et al., 2013). The resin cement used should be compatible with the post surface to improve bond strength, and the same manufacturer's products may have better chemical affinity (Nova et al., 2013). Therefore, in the current study, we used a self-adhesive resin cement from the manufacturer of the FRC post.

According to the literature, a higher pull- out bond strength can be achieved using self-adhesive resin cements (Aleisa et al.,2013; Amaral et al., 2009; Dal Piva et al., 2016; Nova et al., 2013; Pereira et al.,2014). In a study by Sarraf et al. (2019), 201.46 N pull-out force was detected with self-adhesive resin cement. They applied primer to the canal walls before cementation, which was different from our control group. According to the manufacturer's instructions ("Manufacturer's instructions of the primer"), this primer accelerates the polymerization of the cement

and provides etching. This may have led to an increase in the bond strength. Dal Piva et al. (2016) investigated the effect of the alveolar bone level and different cements on the bond strength of FRC posts. They concluded that neither the alveolar bone level or type of cement affected the bond strength. The mean pull-out force in their study was higher than that in the current study. The possible reasons were the tooth type (bovine teeth), longer post cavity (12 mm), application of acid and silane to the post surfaces before cementation (Dal Piva et al., 2016). Contrary to these results, some studies have reported lower bond strength values when using these cements. The discord in the findings can be explained by the low etching and hybridization capacity of the cement (Goracci et al., 2005; Zicari et al., 2008).

Previous research suggested that clinical success of dental posts depends primarily on the frictional retention on root canal walls. Therefore, the hybridization procedure or adhesive bonding are less effective on bond strength or dislodgement forces (Pirani et al., 2005). In the present study, the same bond strength values of the groups can be explained by this sufficient frictional retention.

Many test methods, such as micro-tensile, push-out and pull-out tests, have been used to evaluate the bond strength between root canal dentin and dental post (Cecchin et al., 2016; Dal Piva et al., 2016). The micro-tensile test may lead to a high rate of premature failures. The rate of such failures is reduced in the push-out test, as this technique includes sliced samples which allow to examine the bond strength in different portion of the root canal. The pull-out test makes it possible to investigate the bond strength between dentin and the FRC post in the entire root canal. It also eliminates possible errors that may occur during preparation of the samples (Ebert et al., 2011). In the present study, the pull-out test was selected due to these advantages. On the other hand, this method does not exactly simulate intra-oral conditions. Thus, it would be better to contain low intermittent mechanical forces that come from many directions (Pereira et al., 2014).

Previous studies reported a high adhesive failure rate of the post cement interface (Nova et al., 2013; Shafiei, Saadat and Jowkar, 2018). FRC posts have a highly cross-linked polymer matrix that makes it unable to reactivate the material and also cause a decrease in bond strength between the post and dentin (Nova et al., 2013; Shafiei et al., 2018). In the current study, the failure types of the groups did not show a statistically significant difference (Fig. 2). Dentin-cement interface was the only area that could be affected by the experimental design of the present study. Therefore, the distribution of the fracture types confirmed the result of bond strength.

The single brand combination of fibre post and luting cement and the in vitro conditions are the limitations of the present study. There are limited data available on the cement used, which may be the cause of low bond strength forces. In addition, as the entire procedure was performed without the aid of a microscope, remnants of root canal filling material could have affected the adhesion of the FRC posts (Pereira et al., 2014). Furthermore, the use of human extracted teeth may result in a decrease in bond strength and non-standardization of specimens. The possible reasons were differences in elasticity and mineral-organic phase of the dentin and also the deposition of sclerotic and tertiary dentin (Aleisa et al., 2021; Nova et al., 2013). In present study, the root canal lengths were prepared to ensure standardization of the samples, and the teeth used were maxillary canines. The use of different types of teeth or different root lengths could lead to different results. Therefore, further studies are necessary to examine the bond strength of different types of dental posts, the clinical efficiency of these posts and the effect of microscope use.

5. Conclusions

Within the limitations in the current study;

(1) The re-application of FRC post did not seem to affect the bond strength.
(2) The distribution of failure types showed no difference between the control and re-applied test groups.
(3) The use of the FRC post containing soft polymer micro-fibre offers an easy and safe removal procedure.

Ethical Statement

The ethics committee approval was obtained from Biruni University (Date:02.01.2020, Protocol No:2020/36-13).

Funding

The work was supported by Biruni University Scientific Research Project Department in İstanbul, Turkey (project no: Biruni-BAP-Altyapı-2018-02-04).

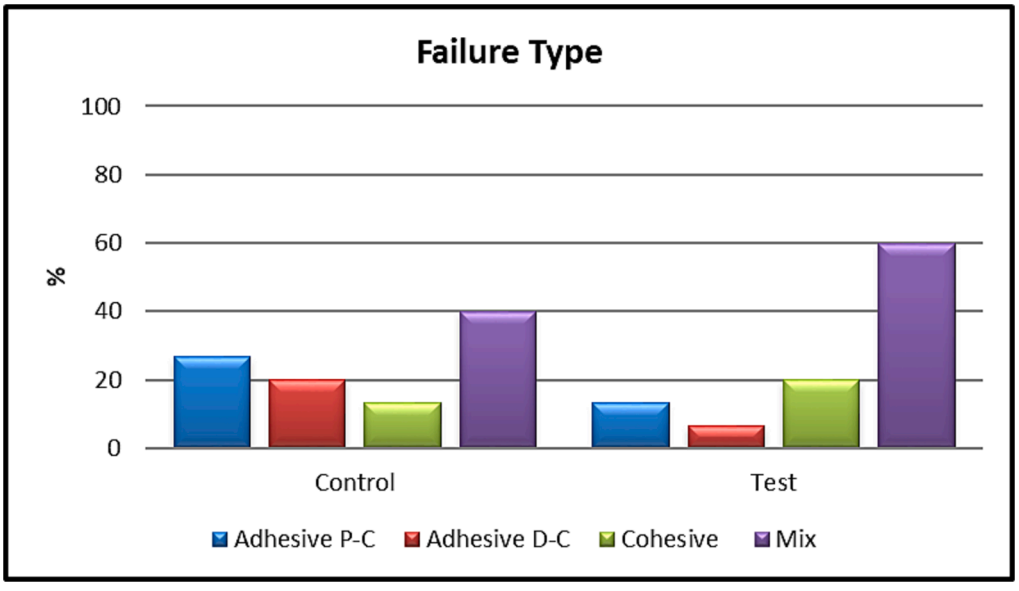


Fig. 2. The graph of the failure type.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This study was presented on the Sivas Cumhuriyet University 1. International Dentistry Congress, Turkey 23–25 November 2021.

Author contributions

All authors contributed to the study conception and design. The first part of samples' preparation was performed by GPS, SSK and TK. The second part of samples' preparation, data collection and analysis were performed by Nİ and EY. The first draft of the manuscript was written by Nİ, EY and SSK, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

References

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 (3), 216–222.

Aleisa, K., Habib, S.R., Ansari, A.S., Altayyar, R., Alharbi, S., Alanazi, S.A.S., Alduaiji, K. T., 2021. Effect of luting cement film thickness on the pull-out bond strength of endodontic post systems. Polymers (basel). 13 (18).

Alkahtany, M.F., 2022. Extrusion bond strength of glass fiber post to radicular dentin after final irrigation using MTAD, EDTA, Pineapple peel extract, and Riboflavin. Photodiagn. Photodyn. Ther. 39, 102982.

Amaral, M., Santini, M.F., Wandscher, V., Amaral, R., Valandro, L.F., 2009. An in vitro comparison of different cementation strategies on the pull-out strength of a glass fiber post. Oper. Dent. 34 (4), 443–451.

Anderson, G.C., Perdigão, J., Hodges, J.S., Bowles, W.R., 2007. Efficiency and effectiveness of fiber post removal using 3 techniques. Quintessence Int. 38 (8).

Arukaslan, G., Aydemir, S., 2019. Comparison of the efficacies of two different fiber post-removal systems: A micro-computed tomography study. Microsc. Res. Tech. 82 (4), 394–401.

Baba, N.Z., Golden, G., Goodacre, C.J., 2009. Nonmetallic prefabricated dowels: a review of compositions, properties, laboratory, and clinical test results. J. Prosthodont. 18 (6), 527–536.

Cagidiaco, M.C., Goracci, C., Garcia-Godoy, F., Ferrari, M., 2008. Clinical studies of fiber posts: a literature review. Int. J. Prosthodont. 21 (4), 328–336.

Cecchin, D., Farina, A.P., Vitti, R.P., Moraes, R.R., Bacchi, A., Spazzin, A.O., 2016. Acid etching and surface coating of glass-fiber posts: bond strength and interface analysis. Braz. Dent. J. 27 (2), 228–233.

Cho, J., Liu, J., Bukhari, E.A., Zheng, F., Kim, D.G., Lee, D.J., 2022. Comparison of post space volume changes following fiber post removal using Er, Cr: YSGG laser versus ultrasonic instrument. J. Prosthodont. 31 (3), 245–251.

Dal Piva, A.M., Campos, F., Alves, M.L., Sousa, R.S., Lima, J.M., Souza, R.O., 2016. Influence of alveolar bone level on the pull-out bond strength of fiber-reinforced composite posts to root dentin. Gen. Dent. 64 (2), e5–e8.

Durski, M.T., Metz, M.J., Thompson, J.Y., Mascarenhas, A.K., Crim, G.A., Vieira, S., Mazur, R.F., 2016. Push-out bond strength evaluation of glass fiber posts with different resin cements and application techniques. Oper. Dent. 41 (1), 103–110.

Ebert, J., Leyer, A., Gunther, O., Lohbauer, U., Petschelt, A., Frankenberger, R., Roggendorf, M.J., 2011. Bond strength of adhesive cements to root canal dentin tested with a novel pull-out approach. J. Endod. 37 (11), 1558–1561.

Goracci, C., Ferrari, M., 2011. Current perspectives on post systems: a literature review. Aust. Dent. J. 56 (Suppl 1), 77–83.

Goracci, C., Sadek, F.T., Fabianelli, A., Tay, F.R., Ferrari, M., 2005. Evaluation of the adhesion of fiber posts to intraradicular dentin. Oper. Dent. 30 (5), 627–635.

Liu, R., Xie, C., Sun, M., Yu, H., 2021. Guided removal of a fractured fiber post and immediate restoration with a digitally prefabricated titanium post-and-core and zirconia crown: A clinical report. J. Prosthet. Dent. 129 (5), 684–689.

Macedo, V.C., Faria e Silva, A.L., Martins, L.R., 2010. Effect of cement type, relining procedure, and length of cementation on pull-out bond strength of fiber posts. J. Endod. 36(9), 1543-1546.

Macedo, V., Souza, N., Silva, A. F. e., Cotes, C., da Silva, C., Martinelli, M., Kimpara, E., 2013. Pullout bond strength of fiber posts luted to different depths and submitted to artificial aging. Oper Dent. 38(4), E128-E133.

Maia, L.M., Júnior, G.M., de Castro Albuquerque, R., de Carvalho Machado, V., da Silva, N.R.F.A., Hauss, D.D., da Silveira, R.R., 2019. Three-dimensional endodontic guide for adhesive fiber post removal: A dental technique. J. Prosthet. Dent. 121 (3), 387–390.

Maia, L.M., Bambirra Junior, W., Toubes, K.M., Moreira Junior, G., de Carvalho Machado, V., Parpinelli, B.C., Ribeiro Sobrinho, A.P., 2022. Endodontic guide for the conservative removal of a fiber-reinforced composite resin post. J. Prosthet. Dent. 128 (1), 4–7.

Manufacturer's instructions of the primer. Retrieved from https://www.kuraraynoritake.eu/pub/media/pdfs/20590_1_Panavia_F_2.0_Brochure_LR.pdf.

Manufacturer's instructions of the post. Retrieved from https://www.overfibers.com/wp-content/uploads/2021/02/HI-REM-PROSTHETIC-01-2021-REV-09.pdf.

Nova, V., Karygianni, L., Altenburger, M.J., Wolkewitz, M., Kielbassa, A.M., Wrbas, K.-T., 2013. Pull-out bond strength of a fibre-reinforced composite post system luted with self-adhesive resin cements. J. Dent. 41 (11), 1020–1026.

Pereira, J. R., da Rosa, R. A., do Valle, A. L., Ghizoni, J. S., Só, M. V. R., & Shiratori, F. K., 2014. The influence of different cements on the pull-out bond strength of fiber posts. J. Prosthet. Dent. 112(1), 59-63.

Pirani, C., Chersoni, S., Foschi, F., Piana, G., Loushine, R.J., Tay, F.R., Prati, C., 2005. Does hybridization of intraradicular dentin really improve fiber post retention in endodontically treated teeth? J. Endod. 31 (12), 891–894.

Rezaei-Soufi, L., Tapak, L., Forouzande, M., Fekrazad, R., 2019. Effects of motion direction and power of Er, Cr:YSGG laser on pull-out bond strength of fiber post to root dentin in endodontically-treated single-canal premolar teeth. Biomater Res. 23, 17.

Sarraf, P., Assadi, A., Kiomarsi, N., Mohammadian, F., Assadi, A., Shamshiri, A.R., 2019. Effect of intracanal medicaments on pull-out bond strength of fiber post cemented with a self-adhesive system. Eur. J. Dent. 13 (03), 420–425.

Scotti, N., Bergantin, E., Alovisi, M., Pasqualini, D., Berutti, E., 2013. Evaluation of a simplified fiber post removal system. J. Endod. 39 (11), 1431–1434.

Shafiei, F., Saadat, M., Jowkar, Z., 2018. Effect of laser heat treatment on Pull-out bond strength of fiber posts treated with different silanes. J. Clin. Exp. Dent 10 (5), e413.

Topçuoğlu, H.S., Topçuoğlu, G., Arslan, H., 2018. The effect of different irrigation agitation techniques on postoperative pain in mandibular molar teeth with symptomatic irreversible pulpitis: a randomized clinical trial. J. Endod. 44 (10), 1451–1456.

Zicari, F., Couthino, E., De Munck, J., Poitevin, A., Scotti, R., Naert, I., Van Meerbeek, B., 2008. Bonding effectiveness and sealing ability of fiber-post bonding. Dent. Mater. 24 (7), 967–977.