Can intra-radicular cleaning protocols increase the retention of fiberglass posts? A systematic review

Abstract: The presence of residues within the root canal after post-space preparation can influence the bond strength between resin cement and root dentin when using fiberglass posts (FGPs). Currently, there is no consensus in the literature regarding what is the best solution for the removal of debris after post-space preparation. This systematic review involved “in vitro” studies to investigate if cleaning methods of the root canal after post-space preparation can increase the retention of FGPs evaluated by the push-out test. Searches were carried out in PubMed (MEDLINE) and Scopus databases up to July 2017. English language studies published from 2007 to July 2017 were selected. 475 studies were found, and 9 were included in this review. Information from the 9 studies were collected regarding the number of samples, storage method after extraction, root canal preparation, method of post-space preparation, endodontic sealer, resin cement, cleaning methods after post-space and presence of irrigant activation. Five studies presented the best results for the association of sodium hypochlorite (NaOCl) and ethylenediamine tetra-acetic acid (EDTA), while in the other 4 studies, the solutions that showed improved retention of FGPs were photon-induced photoacoustic streaming (PIPS), Qmix, Sikko and EDTA. The results showed heterogeneity in all comparisons due to a high variety of information about cleaning methods, different concentrations, application time, type of adhesive system and resin cements used. In conclusion, this review suggests that the use of NaOCl/EDTA results in the retention of FGPs and may thus be recommended as a post-space cleaning method influencing the luting procedure.

Keywords: Resin Cements; Root Canal Irrigants

Introduction

In the rehabilitation of endodontically treated teeth with extensive dental structure losses, the use of fiberglass posts (FGPs) is a viable alternative.¹ FGPs exhibit similar physical properties to dentin, such as elastic modulus, compressive strength, flexure, thermal expansion coefficient, and advantages, such as aesthetics and biocompatibility.²,³,⁴

The retention of the FGPs depends on the adhesive interaction and better adaptation between the resin cement and root dentin.⁵ Failures of FGPs occur by root fracture or debonding between post and resin cement.
null hypothesis was that cleaning methods of the root canal after post-space would not influence the bond strength of FGP's to root dentin. The following research question was investigated: Does the method of root canal cleaning after post-space preparation influence the retention of a fiber post evaluated by push-out tests?

Methodology

Search strategy

This systematic review was conducted by following the guidelines of Transparent Reporting of Systematic Reviews and Meta-analyses (PRISMA-statement). The review question was formulated by the following PICO framework (Patient Population, Intervention, Comparison, and Outcome). The following keywords and their combinations were used: “Root Canal Preparation”[Mesh] OR “Canal Preparation, Root” OR “Canal Preparations, Root” OR “Preparation, Root Canal” OR “Preparations, Root Canal” OR “Root Canal Preparation” OR “root canal cleaning” OR “root canal irrigation” OR “post-space cleaning” OR “post-space preparation cleaning” OR “mechanical cleaning root space” OR “intracanal cleaning”; AND “fiber post” OR “fiber glass” OR “Post and Core Technique”[Mesh] OR “Post-Core Technic” OR “Post-Core Technics” OR “Technic, Post-Core” OR “Technics, Post-Core” OR “Post and Core Technic” OR “Post Technique” OR “Post Techniques” OR “Technique, Post” OR “Techniques, Post” OR “Post Technic” OR “Post Technics” OR “Technic, Post” OR “Technics, Post” OR “Dental Dowel” OR “Dowels, Dental” OR “Dental Dowels” OR “Dowel, Dental” OR “fiber glass post” OR “glass fiber post”; AND “post-space preparation” OR “post-space preparation” OR “endodontic procedures root canal” OR “deep post-space” OR “post-space”.

Eligibility criteria

Literature on the topic in the English language, published from 2007 to July 2017, was selected. All in vitro studies that evaluated the method of root canal cleaning tested by push-out were included.
The inclusion criteria were as follows: *in vitro* studies that used human teeth, the push-out test was included in the methods, a fiber glass post was cemented, resin cement was used to fill the canal, and some irrigant solution method to clean the canal was used, whether activated or not. The exclusion criteria were as follows: studies that did not use human teeth, the push-out test was not described, use of eugenol endodontic sealer, use of solutions for pretreatment after the post-space to improve adhesion, and use of dental canal surface treatment prior to cleaning methods. Duplicated and published studies that did not meet the inclusion/exclusion criteria were excluded from this systematic review.

**Screening and selection**

A comprehensive electronic search was performed through PubMed (MEDLINE) and Scopus databases up to July 2017. A hand searching process was applied based on the references of selected articles. Two endodontic specialist reviewers (L.V.O. and C.C.G.M.) independently ran the described search for eligibility. The lists were then compared, and a definitive consensus regarding the inclusion of articles was reached by discussing each individual article.

**Data extraction and risk of bias**

A data extraction form was developed by the authors to collect general information (title, year of publication, journal, authors, impact factor, aim of study, number of samples, storage after extraction, root canal preparation, method of post-space, moment (time) of post-space before FGPs cementation, endodontic sealer, post resin cement, method of cleaning of root canal after post-space, groups analyzed, presence of final activation, storage/aging, methodology of analysis of samples, hypothesis accepted or rejected, statistical results, conclusion). The JADAD scale assesses the methodological quality of the studies, reporting any potential risk for bias. Each question of this three-point questionnaire needed to be answered with either a yes or a no. Authors elected to exclude all papers on the topic with a JADAD score of 3 or less. Two endodontic specialist reviewers (L.V.O. and C.C.G.M.) evaluated all of the selected studies.

**Results**

Based on this systematic review objective, the lack of information and the heterogeneity of the selected studies, it was not possible to perform valid quantitative analyses of the data or a subsequent meta-analysis. Therefore, a descriptive presentation of the data was adopted.

An initial electronic search identified 473 studies (Figure 1), and the hand searching process identified 2 studies (total of 475 studies). The initial screening of the titles and abstracts resulted in 20 full-text papers that were read in full. The characteristics of the 9 included studies are summarized in Table 1. Eighteen studies that did not meet the inclusion criteria (Figure 1) were excluded. Figure 1. Flow diagram of the systematic review according to the PRISMA Statement.
Table 1. Summary of the characteristics of the 9 included studies.

<table>
<thead>
<tr>
<th>Title</th>
<th>Aim of study</th>
<th>Number of samples</th>
<th>Storage after extraction</th>
<th>Root canal preparation</th>
<th>Method of post-space</th>
<th>Moment (time) of post-space before glass cementation</th>
<th>Endodontic sealer</th>
<th>Resin cement</th>
<th>Method of cleaning after post-space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can intra-radicular cleaning protocols increase the retention of fiberglass posts? A systematic review</td>
<td>To investigate the effects of different root canal treatment protocols on endodontically treated teeth with weakened roots.</td>
<td>42 maxillary canines, 10 premolars, 32 central incisors (n: 4), 90 (n: 15), 40 premolars, 60 maxillary incisors</td>
<td>自来薬、0.2%次亜塩素酸水溶液、0.5%クロラミジンT溶液</td>
<td>Rotary system, Protaper Niti, Dentsply, Protaper motor system, PostSpace PT; Dentsply</td>
<td>After 7 days of storage at 37°C in 100% humidity</td>
<td>AH Plus, Dentsply</td>
<td>Hybrid resin cement</td>
<td>Will be the experimental groups</td>
<td>Continue</td>
</tr>
</tbody>
</table>
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Continuation

Group 1: NaOCl for 1 min; Group 2: NaOCl + EDTA; Group 3: NaOCl/EDTA/NaOCl; Group 4: ultrasonic agitation.

Group 8: Er:YAG laser using with 2% CHX.

Push-out test analysis. A microripper determine a type of failure.

Storage / aging

Thermal cycling regimen of 3,600 cycles in water at 5°C/55°C with at dwell time of 5 s between baths before the post-space.

Presence of final activation

yes, in a third group.

None

Yes. It was used passive ultrasonic irrigation, Er:YAG apical negative pressure, and various types of laser

Methodology of analysis of samples

push-out test, confocal laser scanning microscopy and microscope (Group 3) analysis.

Statically results

No statistically significant differences were found among the root regions (P > 0.05).

Statistical analysis:

- ANOVA with Tukey test for multiple comparisons.

- Push-out test.

- Push-out test.

- Push-out test.

- Push-out test.

- Push-out test.

Conclusion

- Different irrigation procedures differed in post bond strength. The NaOCl/EDTA combination positively affected bond strength; however, no differences were found among the CH, PA, and DW groups.

- In the third group, the highest bond strength was observed with the PIPS technique and there were no statistically significant differences among the groups.

- When the experimental period was over, there were no significant differences among the experimental groups (P > 0.05). Total compositions of bond strength values revealed significant differences between the cervical and apical thirds (P < 0.05).

- The bond strength values were obtained from Group 2 and the lowest bond strength values were obtained from Group 3.

- Bond strength was significantly affected by the luting material (P < 0.0005) and by the luting material (P < 0.0005) and by the IP. The results also showed that the bond strength was significantly affected by the luting material (P < 0.05).

- ANOVA revealed that coronal surface treatment affected the bond strength (P < 0.0001).

- The highest bond strength was obtained in the Silico group.

- Statistical analysis revealed that EDTA/lasing significantly improved the push-out bond strength among the 3 groups. The highest bond strength was obtained in the Silico group.

- The results also showed that the bond strength was significantly affected by the luting material (P < 0.0005).

- Bond strength values in all cervical root segments were significantly higher than the other groups (P < 0.0005).

- The highest bond strength was obtained from Group 2 in cervical root segments than in the other 3 groups.

- In all cervical root segments, the highest bond strength was obtained from Group 2.

- ANOVA revealed that coronal surface treatment affected the bond strength (P < 0.0001).

- The highest bond strength was obtained in the Silico group.

- The results also showed that the bond strength was significantly affected by the luting material (P < 0.0005).
Description of studies

All studies were in vitro, of which a high number of the selected studies had low methodological quality, revealing a high risk of bias, which precluded any statistical analysis of the data.

This systematic review included studies that analyzed the influence of cleaning methods of root canal after post-space preparation on the performance of FGPs evaluated with the biomechanical push-out test. For this investigation, all studies used a fiberglass post in a root canal that was filled with resin-based endodontic sealer. The studies used human teeth, of which the most frequent were premolars, canines, or incisors. The most frequently resin-based endodontic sealer used was AH Plus (Dentsply, York, PA, USA). The timing of post-space after obturation revealed certain heterogeneity, where 4 studies were relieved after 7 days, 2 after 24 hours, 1 after 72 hours, and 1 after 2 weeks post-obturation. One study did not show the period for post-space preparation. Seven studies used the association of NaOCl/EDTA in some of their experimental groups.8,17,23,24,25,26,27 Chlorhexidine appeared in 3 studies, 18,25,26 although in one of these studies, there was also the presence of chlorhexidine in the composition of a commercial solution called Qmix.26 Other solutions that were also tested included NaOCl and EDTA used individually, with some variations of time and concentration,8,16,18,26,27 of which the most used concentrations were 5.25% NaOCl and 17% EDTA both for a maximum of 1 minute. Regarding the methods of activation of the irrigating solutions, 5 studies8,23,24,27,28 reported using some type of activation method to potentiate the cleaning effect. Most failure modes were of the adhesive type at the junction of the root dentin and resin cement, which is the retention region of the FGPs. All studies were classified as having a high risk of individual bias.

Discussion

To the best of the authors’ knowledge, this systematic review is the first to summarize in vitro data on the influence of cleaning methods on root canals after post-space preparation on the performance of FGPs luting by dual resin cements. The retention between root dentin and resin cement is a critical point for luting FGPs, since interference in the resin-dentin diffusion zone affects the longevity of the FGPs.23,40,41 Although several studies have evaluated the effect of post surface treatments and cementation strategies on the retention of FGPs, the presence of the smear layer and debris along the post-space canal walls can also affect the optimal dentin adhesion.6 The role of cleaning methods after post-space supports clinicians in terms of evidence-based decision making. Therefore, the tested hypothesis was rejected.

For anatomical reasons, the apical third of the root presents deep, narrow irregular dentin and a fewer number of dentinal tubules, which are often sclerotic and render any adhesive application protocol difficult to control.42 In addition, another reason that explains the lower bonding potential at the deeper root canal dentin is the distance from the light activation, resulting in a lower monomer conversion and reduced resin cement polymerization.5,41,43 Endodontic sealer residues might also interfere with the polymerization of the resin cement.44 The presence of the smear layer impairs an adequate contact between the acidic methacrylates of self-adhesive resin cements and the underlying dentin during adhesive procedures, thus interfering with bond strength.19 The partial or total debris removal previous to resin cement insertion into the root canals might improve post retention and, consequently, the bond strength.34 Acidic solutions such as EDTA have shown good results in removing the smear layer but do not adequately demineralize dentin or enhance the contact of the self-adhesive resin cements with dentin.45 In contrast, NaOCl solution alone partially removes the smear layer, causing removal of dentinal proteins and making the dentin surface hydrophilic, which could impair resin cement polymerization.46

The current study was conducted by in vitro studies due to the difficulty of evaluating this parameter in vivo. Only human teeth were included in this study because they are closest to the clinical conditions in which the posts are installed. However, bovine teeth or artificial devices could be used to evaluate FGPs retention. Although there is a wide variability of endodontic sealers in the dental market with different compositions, studies that did not use endodontic
resin sealers were excluded from the present study because canals obturated with eugenol-containing sealers may have reduced polymerization of resin cements used in GFPs cementation.\textsuperscript{47-49} To standardize the samples, only studies that performed the bond strength test by using push-out test were included, since it is a commonly used test to evaluate GFPs as it provides a better estimate of the bond strength.\textsuperscript{50}

In relation to the treatment of the dentin surface for the removal of debris previous to GFPs cementation, there are several forms, such as aluminum oxide blasting, rotary brushes and irrigating solutions that are activated or not.\textsuperscript{17} Regarding the irrigation solutions, we verified the use of NaOCl, EDTA, chlorhexidine, distilled water, QMix (Dentsply Tulsa Dental), phosphoric acid, alcohol, Sikko Tim (VOCCO, Germany), and citric acid.\textsuperscript{8} These irrigant solutions promote flushing of the flue and dissolve the tissues, while they display antimicrobial characteristics in the removal of the smear layer formed during the post-space of the root canal.\textsuperscript{51} Considering these criteria, only nine studies were included, of which five studies showed better results for the combination of NaOCl/EDTA, regardless of the sequence of the use.\textsuperscript{17,23,25,27,28} The increased GFP bond strength after the combination of NaOCl/EDTA solutions\textsuperscript{17,23,25,27} may be attributed to the ability of the solutions to remove the smear layer, thus improving cement contact and penetration into dentinal tubules.\textsuperscript{25} Recently, the use of irrigation activated by ultrasonic, lasers, and negative apical pressure (Endovac) has been discussed.\textsuperscript{52} However, the activation does not necessarily imply a better bond strength.\textsuperscript{23,24}

In addition, the association of NaOCl/EDTA with ultrasonic agitation had a better performance when compared with non-activated NaOCl/EDTA on the removal of debris capacity.\textsuperscript{28} Ultrasonic application showed good results in the most important retention areas, since it is possible to reach the entire length of the root canal with irrigant solutions.\textsuperscript{53} In addition, distilled water was used frequently as the final irrigation.\textsuperscript{17,24,25,27,28} Boosting the effect of cleaning methods may reduce precipitate formation.\textsuperscript{54} The higher bond strength by using this protocol was explained by the removed smear layer and opened dentinal tubules.\textsuperscript{28}

The association of non-activated NaOCl/EDTA also showed satisfactory results when using self-adhesive resin cement for GFPs cementation.\textsuperscript{17} However, when cemented with an etch-and-rinse adhesive system, the best results were assigned to NaOCl 1\% with ultrasonic activation,\textsuperscript{17} which leads us to believe that each adhesive strategy should be adapted to each irrigant procedure. Knowing that self-adhesive cement has been widely used because of its chemical or micromechanical retention on the dentin surface,\textsuperscript{55} the association of NaOCl/EDTA can be considered as an excellent choice for root canal cleaning after post-space on self-etch and self-adhesive strategies involving adhesive cementation, as the acid-resin monomers of these cements may not be as effective as phosphoric acid in penetrating and modifying the smear layer of the root canal. The resin cement type and the composition can negatively interact with the cleaning agents. This aspect is more sensitive for the self-adhesive system, since it does not use phosphoric acid. The same irrigants may influence the polymerization reaction and, consequently, the bonding interaction.\textsuperscript{23} There is a scarcity of studies testing different irrigants with different self-etching resin cements. In general, the RelyX U200 is less sensitive with the use of NaOCl and EDTA irrigation.\textsuperscript{23,45}

On the other hand, the isolated or alternate use of the NaOCl and EDTA solutions, intensified by some methods of activation, was not as effective as the distilled water activated with PIPS.\textsuperscript{24} PIPS is a novel laser agitation technique used with an erbium:yttrium-aluminum-garnet (Er:YAG) laser.\textsuperscript{56,57} The higher efficiency of this technique is based on photoacoustic and photomechanical action without the need to extend the root apex; each propellant reacts with the water molecules, constituting expansion and succession waves that create intermittent fluid.\textsuperscript{56} Such results support the use of Er:YAG laser activation or PIPS to improve the effectiveness of the final irrigation after post-space preparation; however, more studies are needed to confirm this finding.\textsuperscript{24}

Another cleaning method option that also exhibited good results was a commercial product named Sikko Tim (VOCCO, Germany), which is an ethyl acetate and acetone-based cleaning agent. The group treated with Sikko showed the highest bond strength values
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compared to NaOCl/EDTA. However, it could not remove the smear layer effectively and differed with an association of 17% EDTA for 60 s and 5% NaOCl for 15 s, which appeared to be satisfactory. The product Sikko did not show satisfactory results regarding the opening of the dentin tubules, as well as the removal of the smear layer and cement remnants, and thus has not been indicated for the self-etching system. Therefore, more studies are needed to evaluate the use of this solution. Another study using NaOCl and EDTA independently found better GFP bond strength when 14% EDTA irrigation and the self-adhesive resin cement were used. This fact can be attributed to the low pH of EDTA, in addition to its ability to act as a chelator by removing the smear layer and cleaning the root canal. EDTA removes calcium from hydroxyapatite and is linked to non-collagenous protein. Thus, collagen fibrils are preserved, and they subsequently improve the infiltration of the resin material, resulting in higher adhesion strength between resin cement and root dentin. Chlorhexidine has also been used as a possible irrigation solution post-space preparation. Three studies used chlorhexidine, but only one had satisfactory results by using a commercial formulation named QMix. It is composed of EDTA, chlorhexidine and a surfactant, supporting the removal of the smear layer while opening dentin tubules and simplifying the irrigation protocol. This solution decreases the surface tension of the root dentin, thus increasing its wet ability, as well as its capacity to contact the smear layer and the underlying dentin to improve irrigation.

The result of the present systematic review should be interpreted with caution considering that in vitro studies have limitations regarding simulating in vivo conditions. The variety of cleaning methods, different concentrations, application time, type of adhesive system and resin cements used result in heterogeneous comparisons, which reduce standardization and demonstrate a high risk of bias. Therefore, more attention should be placed on the influence of root canal cleaning methods after post-space on the cementation of FGPs because the presence of residues may negatively interfere with the adhesion of the fiber post to the root canal.

Conclusion

Based on the findings of this systematic review, it is possible to conclude that root canal cleaning methods after post-space, whether activated or not, can affect the bond strength of FGPs. Despite the variability of irrigation protocols in most of these studies, the current findings may suggest that the use of NaOCl/EDTA could be recommended for post-space irrigation when luting a fiber post, since it demonstrated a better performance compared to other irrigation solutions.

References


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