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RESEARCH AND EDUCATION

Effects of different peracetic acid formulations on post space radicular dentin

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ABSTRACT

Statement of problem. The optimal irrigating solution with antimicrobial and dentin cleansing properties for post space preparation for fiber posts is unclear. Peracetic acid is one option but is available in various chemical formulations that require evaluation.

Purpose. The purpose of this in vitro study was to evaluate dentin surface cleanliness based on the presence of a smear layer and the number of open dentin tubules. It also investigates the chemical composition of residues after canal irrigation with a 1% peracetic acid solution (PA) at low or high concentration of hydrogen peroxide during the preparation of intracanal fiber posts.

Material and methods. After filling the root canals of 40 mandibular incisors, a rotary instrument was used for intracanal preparation to place fiber posts. The teeth were divided into 4 groups (n=10) according to the post space irrigation protocol as follows: CG (control): distilled water; NA (NaOCl): 2.5% sodium hypochlorite; LH: PA with low concentration of hydrogen peroxide; and HH: PA with high concentrations of hydrogen peroxide. After irrigation, the teeth were sectioned, and the intracanal dentin surface was subjected to analysis using energy dispersive spectroscopy to evaluate chemical composition and to scanning electron microscopy (×500) to evaluate the presence of the smear layer. The number of open dentin tubules was measured by scanning electron microscopy analysis (×2000) using photo-editing software. ANOVA and the Tukey test (α=.05) were used to evaluate the data, except for the presence of a smear layer, for which the Kruskal-Wallis and Dunn tests were used (α=.05).

Results. The highest concentrations of oxygen in the dentin residues were detected in LH and HH (P<.05); CG and NA showed similar oxygen concentrations (P>.05). NA had a higher concentration of chlorine (P<.05), whereas LH had a lower amount of smear layer and a larger number of open dentin tubules than the other groups (P<.05). These were equivalent to each other (P>.05), except for HH, which also had a larger number of open dentin tubules than CG and NA (P<.05).

Conclusions. PA 1% with a low concentration of hydrogen peroxide yielded a lower amount of smear layer and a larger number of open dentin tubules in the dentin of the post space when compared with PA 1% with a high concentration of hydrogen peroxide, despite maintaining a similar oxygen concentration in these dentin residues. (J Prosthet Dent 2018;120:92-8)

Endodontically treated teeth may require intracanal posts for restoration, especially when there is extensive loss of tooth substrate.[1,2] In these situations, the endodontic filling is partially removed with manual and/or rotary instruments.[3-6]

During the preparation phase, there is the risk of microbial contamination of the post space, which may lead to future periodontal complications.[7] Additionally, the smear layer that is formed may compromise the adhesive system of the post in the post space.[8,9]

After preparation of the post space, an irrigation protocol that includes both antimicrobial and root dentin cleaning properties is recommended.[7,9] Sodium hypochlorite is typically recommended for endodontic irrigation; however, it does not remove the smear layer

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Clinical Implications

The post space should be irrigated with solutions that have antimicrobial activity and also reduce the smear layer. Peracetic acid addresses these needs, although the effects of different formulations on the root dentin have yet to be determined.

completely and interferes with the bonding of fiber posts.[10-13]

Other solutions including chlorhexidine digluconate, phosphoric acid, and ethylenediaminetetraacetic acid (EDTA) have been proposed to achieve the same goals.[14-22] However, these solutions also have adverse effects and/or limited antimicrobial activity, which makes them less than ideal for irrigating the post space before cementation.[23]

Peracetic acid has been proposed as an alternative solution for irrigating root canals, given that it has antimicrobial activity, satisfactory surface cleaning capability, and dentin penetrability.[24-30] The recommended solution for endodontic use is composed of hydrogen peroxide and acetic acid.[29] However, hydrogen peroxide can interfere with the dentin cleaning of endodontic irrigation protocols.[31]

Commercial peracetic acid solutions are available with both high and low concentrations of hydrogen peroxide.[32] However, the effects of these solutions on the post space dentin before intracanal post cementation are unknown.

The purpose of this study was to use scanning electron microscopy (SEM) and energy dispersive spectroscopy (EDS) analysis to evaluate the cleaning capacity of 1% peracetic acid solution with low or high concentrations of hydrogen peroxide to chemically analyze the residues, to examine the presence of a smear layer, and to count the number of dentin tubules in the space prepared for intraroot post placement. The null hypothesis was that the final irrigation of the canal space with solutions with different concentrations would not present statistically significant differences.

MATERIAL AND METHODS

This study was approved by the research ethics committee of the Araraquara Dental School (registration number 44018715.9.0000.5416). Forty maxillary central incisors were obtained from patients who needed extractions for periodontal disease and were stored in 1% thymol solution at 4°C. All teeth were radiographed in the buccolingual and mesiodistal directions to verify the presence of a single root canal with similar endodontic anatomy. Those that did not meet these requirements were discarded and replaced.

Table 1. Mean ±standard deviation of frequency distribution (%) of oxygen and chlorine present in smear layer on dentin surface of intracanal space prepared for fiber post

Element	CG	NA	LH	HH
Oxygen	96.35 ±1.33^{b}	96.16 ±1.44^{b}	98.23 ±1.19^{a}	98.64 ±1.45^{a}
Chlorine	2.33 ±1.36^{b}	3.98 ±1.22^{a}	1.75 ±1.18^{b}	1.16 ±1.11^{b}

CG, distilled water (control); HH, peracetic acid solution with high concentration of hydrogen peroxide; LH, peracetic acid solution with low concentration of hydrogen peroxide; NA, 2.5% sodium hypochlorite; SD, standard deviation. Different superscript letters in same row signify statistical difference (P<.05).

The teeth were sectioned by using a double-sided diamond disk (KG Sorensen) at 17 mm from the root apex. The root canals were prepared with a series of shaping and finishing files (ProTaper; Dentsply Sirona) up to the F2 size to achieve a standardized working length of 16 mm, according to the manufacturer's recommendations.

At each change of the instruments, the root canal was irrigated with 5 mL of 2.5% sodium hypochlorite solution (Asfer). At the end of the chemical-mechanical preparation, the root canal was irrigated with 5 mL of 17% EDTA (Biodinâmica) and maintained inside the canal for 3 minutes. The final irrigation was carried out with 10 mL of 2.5% sodium hypochlorite solution. The root canal was aspirated and dried with absorbent paper points, size F2 (ProTaper; Dentsply Sirona).

The root canals were obturated with size F2 gutta percha points (ProTaper; Dentsply Sirona) and epoxy resin-based cement (AH Plus; Dentsply Sirona) by using a single-cone technique (Touch'n Heat; Sybron Endo) sectioned with a warmed spatula 1 mm short of the cervical root surface. The cervical opening of the root canal was restored with glass ionomer cement (Vidreon; SS White), and the roots were immediately immersed in distilled water and stored at 37°C for 7 days.

After the immersion period, the restoration with glass ionomer cement was removed with a diamond rotary instrument (N. 1012; KG Sorensen). The post space was prepared and the gutta percha removed with a rotary instrument (Post Preparation; Hels) with 1.05 mm (apical) and 1.8 mm (cervical) dimensions at low speed (8000 rpm) without cooling, with a cervical extension of 12 mm toward the root apex. One longitudinal groove was made externally in the buccal and lingual root surfaces.[33-37]

The roots were divided into 4 groups (n=10) according to the irrigation protocol of the prepared post space as follows: CG (control) distilled water; NA (NaOCl), 2.5% sodium hypochlorite solution (Asfer); LH (LCPA), 1% peracetic acid solution (Sigma; Aldrich) with a low concentration of hydrogen peroxide (40% peracetic acid and 8% hydrogen peroxide); and HH (HCPA), 1% peracetic acid solution (Peresal; Profilática) with a high concentration of hydrogen peroxide (4% peracetic acid and 26% hydrogen peroxide).

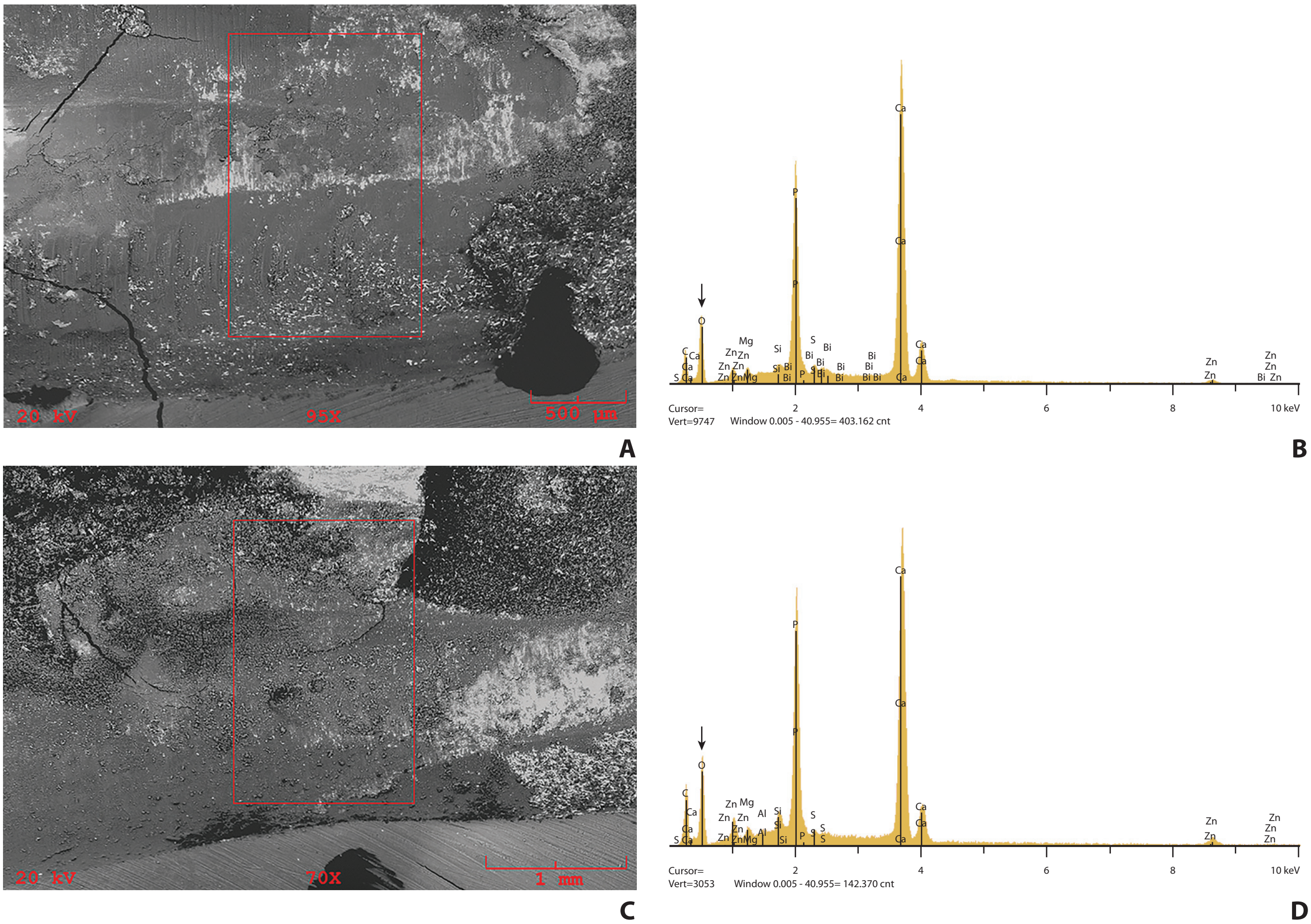

Figure 1. A, C, Representative scanning electron microscopy images of site of dentin residues. B, D, Energy dispersive spectroscopy analysis showing presence of oxygen. Black arrow indicates presence of oxygen. A, B, Control distilled water; 2.5% sodium hypochlorite). C, D 40% peracetic acid and 8% hydrogen peroxide; 4% peracetic acid and 26% hydrogen peroxide. A, Original magnification, ×95. C, Original magnification, ×70.

The post space was irrigated with 5 mL of the solution for 1 minute and kept for 3 minutes without stirring. After irrigation, the post space was aspirated with a 0.48-mm-diameter suction tube (Capillary Tips; Ultradent Products, Inc) and dried with size F2 absorbent paper points (ProTaper; Dentsply Sirona). The roots were then split longitudinally in a buccolingual direction with a chisel.

The distal surface of each root was selected for microscopic analysis. The specimens were mounted on metal stubs, oven-dried at 37°C for 5 days, and stored for 2 days in a closed chamber containing silica gel. The smear layer was chemically analyzed using chemical SEM-EDS microanalysis (EVO 50; Carl Zeiss) at ×75 and ×95 magnification within an area measuring 250 μm^2 of the middle third of the post space. The relationship between the presence of oxygen and chlorine was measured as a percentage of the smear layer surface through EDS and submitted to ANOVA and the Tukey test (α=.05).

The specimens were sputter-coated with metal and assessed under SEM (EVO 50; Carl Zeiss) in the same area in which the images were obtained for EDS. Four different fields were analyzed, and a representative image for each specimen was obtained at ×500 and ×2000 magnification.

The images obtained at ×500 magnification were used to evaluate the presence of residues (smear layer) on the dentin surface. Scores ranging from 0 to 4 were assigned according to the degree of residue observed by following the parameters described by Aranda-Garcia et al.[38] The data were submitted to the Kruskal-Wallis test followed by the Dunn test for multiple comparisons (α=.05).

The images obtained at ×2000 magnification were used to quantify the presence of open dentin tubules through visual counting using photo-editing software (Adobe Photoshop CS6; Adobe Systems), according to the parameters described by Arslan et al.[39] The data were submitted to ANOVA and the Tukey test (α=.05).

RESULTS

The presence of calcium and phosphorus was identified in all specimens. LH and HH showed higher concentrations of oxygen in the smear layer than did the other groups (P<.05), but similar concentrations to each other

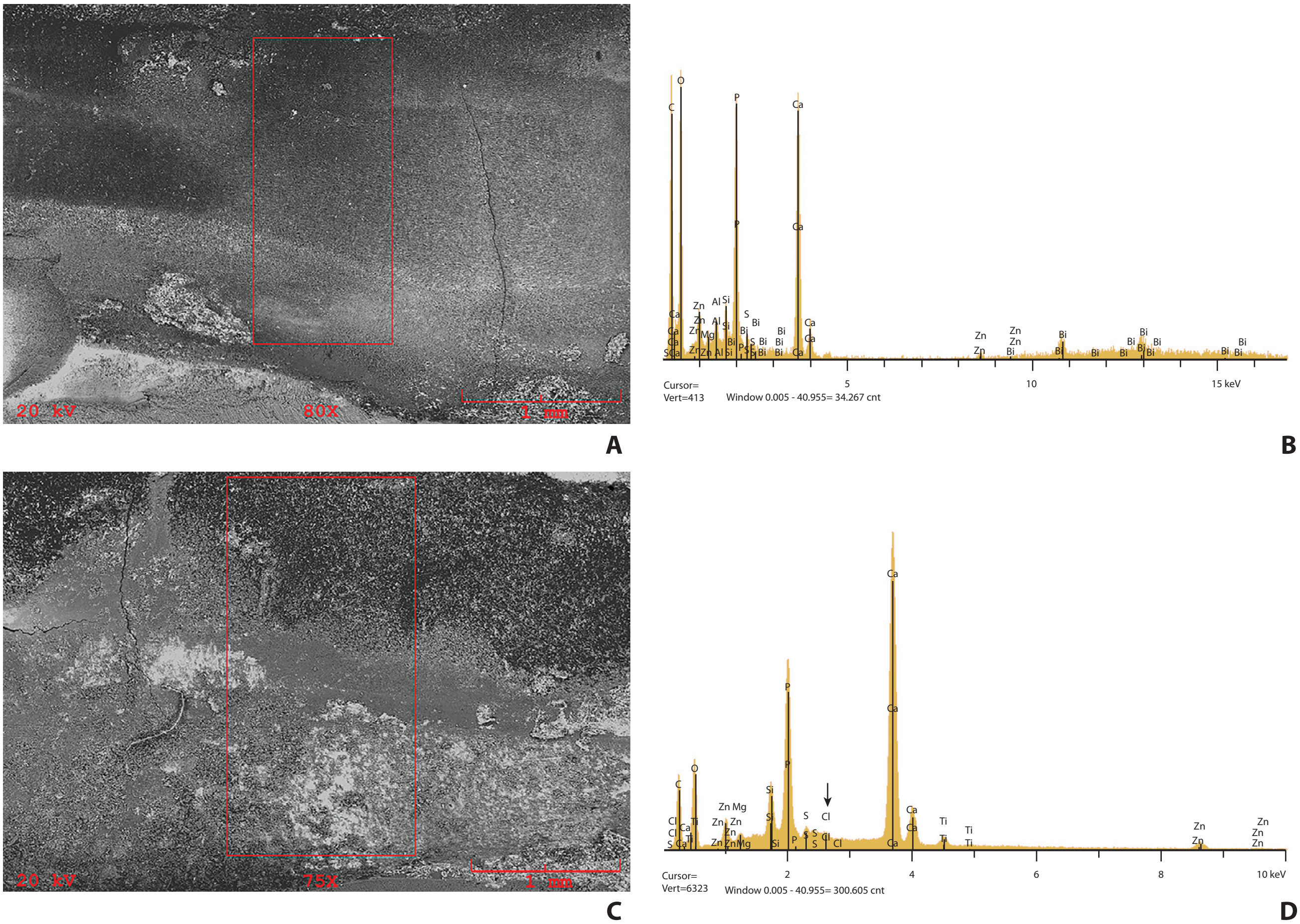

Figure 2. A, C, Representative scanning electron microscopy images of site of dentin residues. B, D, Energy dispersive spectroscopy analysis showing presence of chlorine. Black arrow indicates presence of chlorine. A, B, Control distilled water; 2.5% sodium hypochlorite). C, D 40% peracetic acid and 8% hydrogen peroxide; 4% peracetic acid and 26% hydrogen peroxide. A, Original magnification, ×80. C, Original magnification, ×75.

Table 2. Median, maximum, and minimum scores, first and third quartiles of scores attributed to presence of smear layer on dentin surface of intracanal space prepared for fiber post

Scores	CG	NA	LH	HH
Median	4^b	4^b	2^a	3.5^b
Minimum	4	2	2	3
Maximum	4	4	3	4
Q1	4	4	2	3
Q3	4	4	2	4

CG, distilled water (control); HH, peracetic acid solution with high concentration of hydrogen peroxide; LH, peracetic acid solution with low concentration of hydrogen peroxide; NA, 2.5% sodium hypochlorite; Q1, first quartile; Q3, third quartile. Different superscript letters in same row signify statistical difference ($P<.05$).

($P>.05$). No difference was found between CG and NA ($P>.05$). NA showed a higher concentration of chlorine in the smear layer than did the other groups ($P<.05$), which were similar to each other ($P>.05$). Table 1 shows the mean and standard deviation of the oxygen and chlorine percentage in the smear layer.

Figure 1 illustrates the site of the residues and the profile of the presence of oxygen. Figure 2 illustrates the site of the residues and the profile of the presence of chlorine.

LH showed a lower incidence of smear layer on the dentin surface of the post space than did the other groups ($P<.05$), which did not differ from each other ($P>.05$). Table 2 shows the median, maximum, and minimum scores and the first and third quartiles of the experimental groups. Figure 3 shows the characteristic of the smear layer present in each of the experimental groups.

LH had a greater number of open dentin tubules than the other groups ($P<.05$). HH had a greater number of open dentin tubules than CG and NA ($P<.05$), which, showed a similar number of open dentin tubules ($P>.05$). Table 3 shows the arithmetical mean, standard deviation, minimum, and maximum number of open dentin tubules for each of the experimental groups. Figure 4 shows the characteristic of the open dentin tubules in the experimental groups.

DISCUSSION

The preparation of the post space for intracanal posts may leave residues on the post space surface because of the mechanical action of rotary instruments. However,

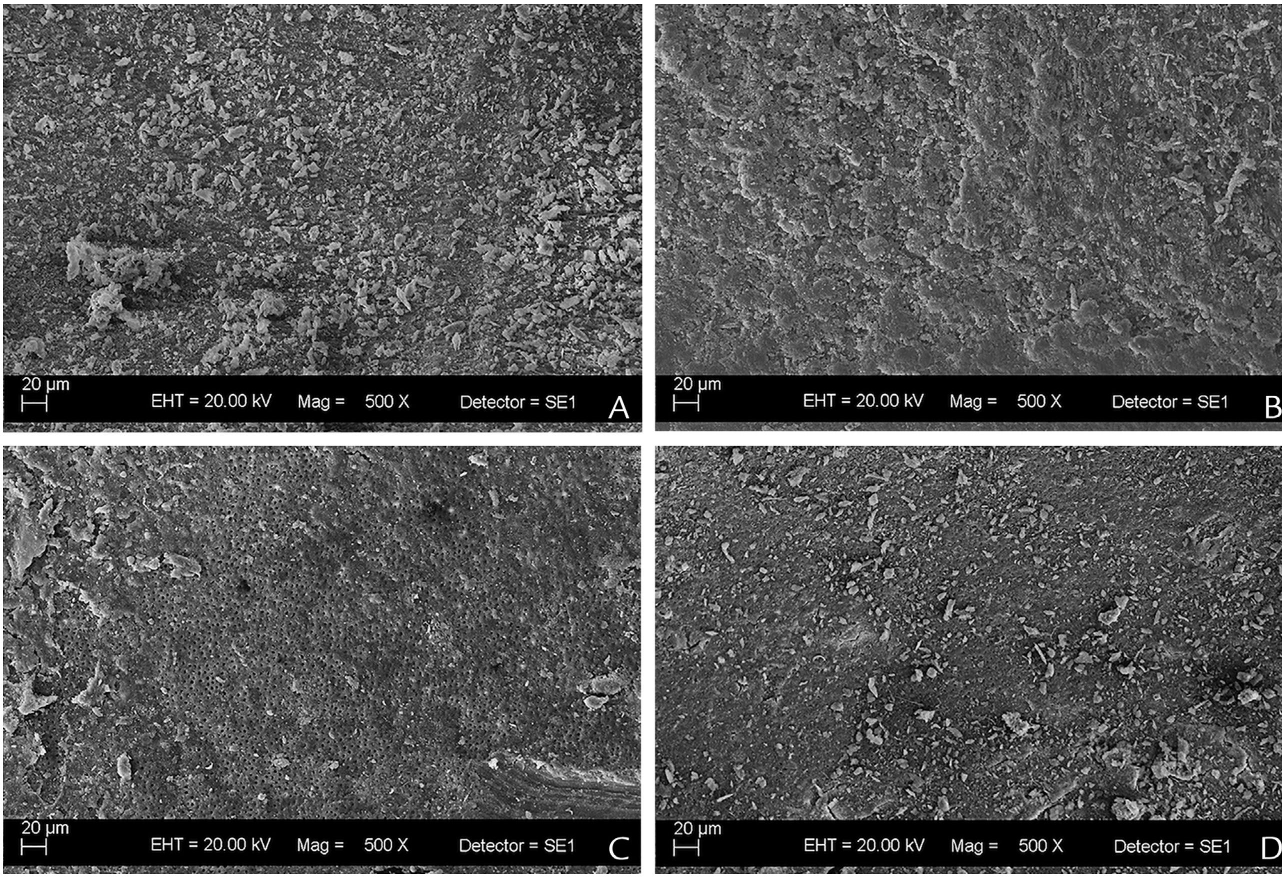

Figure 3. Representative image of smear layer present. A, Control distilled water. B, 2.5% sodium hypochlorite. C, 40% peracetic acid and 8% hydrogen peroxide. D, 4% peracetic acid and 26% hydrogen peroxide. (Original magnification, ×500.)

Table 3. Mean ±standard deviation, and maximum and minimum scores of number of dentin tubules

No Tubules	CG	NA	LH	HH
Mean ±SD	21.45 ±10.98[c]	39.81 ±13.91[c]	130.81 ±69.10[a]	84.45 ±29.86[b]
Vmax–Vmin	42–9	58–16	310–60	130–51

CG, distilled water (control); HH, peracetic acid solution with high concentrations of hydrogen peroxide; LH, peracetic acid solution with low concentration of hydrogen peroxide; NA, 2.5% sodium hypochlorite; SD, standard deviation; Vmax, maximum score; Vmin, minimum score. Different superscript letters in same row signify statistical difference (*P*<.05).

these residues are different from the smear layer caused by chemical-mechanical preparation, which also contains endodontic cement debris.[15] As a result, final irrigation solutions routinely used in endodontic treatment are not recommended for post space irrigation, given that they do not possess satisfactory dentin cleaning and antimicrobial properties.[27,31,38] Peracetic acid was used in this study because it has both properties.[16,25,26] However, it had different effects on the root dentin of the space prepared for the placement of intracanal posts, depending on the chemical formulations with different concentrations of hydrogen peroxide.

Although oxygen was present in all specimens, the concentration was significantly higher in groups in which the peracetic acid solution was used. The solution comprised hydrogen peroxide, acetic acid, and acetyl hydroperoxide, which release hydroxyl and free radicals during the chemical decomposition process, resulting in oxygen and acetic acid.[17,25,29] The highest chlorine concentration was observed in NA, because the solution yields hypochlorous acid and sodium hydroxide.[13,26] Moreover, the peracetic acid solution has no chlorine in its chemical composition. The possible presence of this ion in the smear layer of some specimens finally irrigated with peracetic acid solution may be a by-product of the sodium hypochlorite used during the chemical-mechanical preparation of the root canals.[10,13,18]

The ability of peracetic acid to clean the dentin surface is satisfactory, regardless of its concentration in the solution, and is similar to that of EDTA.[19,25] In this study, the solution with a low concentration of hydrogen peroxide was more effective at removing the smear layer, suggesting that the presence of residues is directly related to the concentration of hydrogen peroxide present in the solution. This finding agrees with that of Scelza et al,[31] who reported that endodontic irrigation associated with hydrogen peroxide was less effective in removing the smear layer of root dentin.

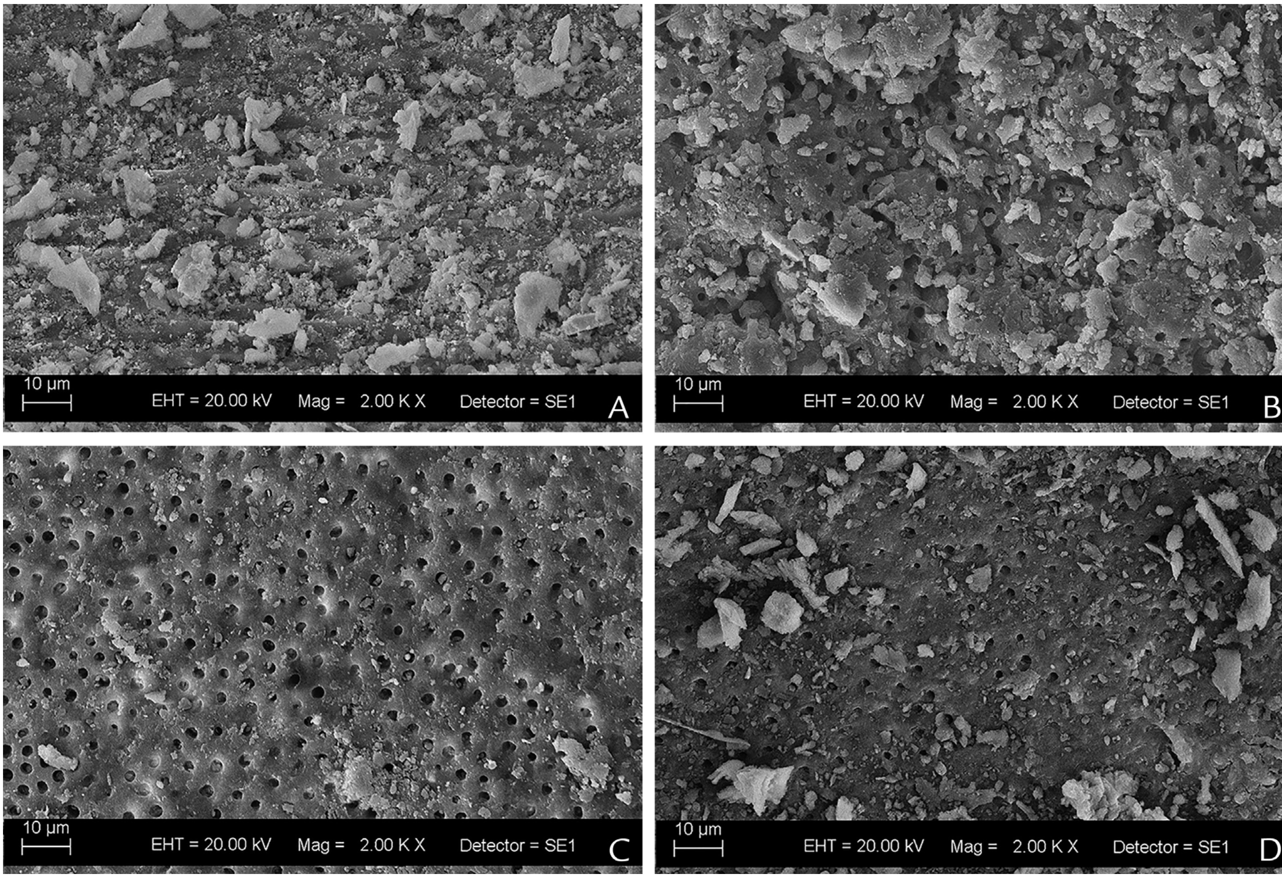

Figure 4. Representative image of presence of open dentin tubules. A, Control distilled water. B, 2.5% sodium hypochlorite. C, 40% peracetic acid and 8% hydrogen peroxide. D, 4% peracetic acid and 26% hydrogen peroxide. (Original magnification, ×2000.)

Peracetic acid cleared more of the dentin tubules than did other irrigating solutions because of its demineralizing action, irrespective of the hydrogen peroxide solution concentration.[24] Because hydrogen peroxide concentration is directly associated with the presence of residues on the dentin wall, the solution with the lowest concentration (Sigma) also yielded the highest number of open tubules.

As the bonding of adhesive resin-based cements used for fiber posts involves interaction with the collagen fibers of the root dentin, reducing the residue between them to a minimum would be desirable.[14,20-22] Also, as the smear layer produced by rotary instruments is distributed both on the intertubular dentin surface and over the openings of the dentin tubules, peracetic acid solution (1%) with a low concentration of hydrogen peroxide was the most effective final irrigation process[30]; furthermore, this solution has satisfactory antimicrobial activity.[16,27,28]

Although 1% peracetic acid solution was the most effective final irrigation method, it also showed high residual concentrations of oxygen, which would interfere with the adhesion of any resin cement by inhibiting complete polymerization.[29] The findings reported here reinforce those of Pereira et al,[33-36] who demonstrated that the highest bond strength is provided by glass ionomer cements. This may make conventional glass ionomer cement the most suitable for intracanal post cementation, even when peracetic acid is used to clean the post space. In the present study, the post space was prepared with rotary instruments without water cooling. The use of copious irrigation might prevent the development or accumulation of debris, though this has yet to be demonstrated.[37]

The presence of residues containing calcium and phosphorus on the root dentin was observed in all specimens. These chemicals are also routinely detected in the smear layer after the chemical-mechanical preparation of post spaces.[10] This fact supports the use of glass ionomer, which bonds to the tooth substrate by means of chemical bonds from its carboxylic radicals to the calcium ions existing either in the enamel, dentin, or cement structures.[33]

Even though 1% peracetic acid solution at low hydrogen peroxide concentration demonstrated adequate cleaning of the preparation for fiber post placement, further studies are needed to evaluate the impact of this solution, as well as the effects of hydrogen peroxide on the bond strength of resin-based adhesive systems.

CONCLUSIONS

Within the limitations of this in vitro study, the following conclusions were drawn:

1. Final irrigation of the canal space with 1% peracetic acid produced a higher concentration of oxygen in the smear layer than did the remaining solutions tested ($P<.05$).
2. The solution with a low hydrogen peroxide concentration yielded less residue on the root dentin and a higher incidence of open dentin tubules when compared with other solutions ($P<.05$).

REFERENCES

1. Figueiredo FE, Martins-Filho PR, Faria-E-Silva AL. Do metal post-retained restorations result in more root fractures than fiber post-retained restorations? A systematic review and meta-analysis. J Endod 2015;41:309-16.
2. Victorino KR, Kuga MC, Duarte MA, Cavenago BC, Só MV, Pereira JR. The effects of chlorhexidine and ethanol on push-out bond strength of fiber posts. J Conserv Dent 2016;19:96-100.
3. Tsintsadze N, Garcia M, Grandini S, Goracci C, Ferrari M. Effect of Reciproc endodontic treatment with three different post space preparation instruments on fiber post retention. Am J Dent 2015;28:251-4.
4. Pulido CA, de Oliveira Franco AP, Gomes GM, Bittencourt BF, Kalinowski HJ, Gomes JC, et al. An in situ evaluation of the polymerization shrinkage, degree of conversion, and bond strength of resin cements used for luting fiber posts. J Prosthet Dent 2016;116:570-6.
5. Daleprane B, Pereira CN, Bueno AC, Ferreira RC, Moreira AN, Magalhães CS. Bond strength of fiber posts to the root canal: Effects of anatomic root levels and resin cements. J Prosthet Dent 2016;116:416-24.
6. Uzun I, Keskin C, Özsu D, Güler B, Aydemir H. Push-out bond strength of oval versus circular fiber posts irradiated by erbium-doped yttrium aluminum garnet laser. J Prosthet Dent 2016;116:425-30.
7. Reyhani MF, Ghasemi N, Rahimi S, Milani AS, Barhaghi MH, Azadi A. Apical microleakage of AH Plus and MTA Fillapex sealers in association with immediate and delayed post space preparation: A bacterial leakage study. Minerva Stomatol 2015;64:129-34.
8. Akyuz Ekim SN, Erdemir A. Effect of different irrigant activation protocols on push-out bond strength. Lasers Med Sci 2015;30:2143-9.
9. Arisu HD, Kivanç BH, Sağlam BC, Şimşek E, Görgül G. Effect of post-space treatments on the push-out bond strength and failure modes of glass fiber posts. Aust Endod J 2013;39:19-24.
10. do Nascimento AL, Busanello FH, Só MV, Kuga MC, Pereira JR, Grecca FS. Residues of different gel formulations on dentinal walls: A SEM/EDS analysis. Microsc Res Tech 2015;78:495-9.
11. Jardine AP, Rosa RA, Santini MF, Wagner M, Só MV, Kuga MC, et al. The effect of final irrigation on the penetrability of an epoxy resin-based sealer into dentinal tubules: A confocal microscopy study. Clin Oral Investig 2016;20:117-23.
12. da Cunha LF, Furuse AY, Mondelli RF, Mondelli J. Compromised bond strength after root dentin deproteinization reversed with ascorbic acid. J Endod 2010;36:130-4.
13. Varise TG, Estrela C, Guedes DF, Sousa-Neto MD, Pécora JD. Detection of organochlorine compounds formed during the contact of sodium hypochlorite with dentin and dental pulp. Braz Dent J 2014;25:109-16.
14. Haragushiku GA, Back ED, Tomazinho PH, Baratto Filho F, Furuse AY. Influence of antimicrobial solutions in the decontamination and adhesion of glass-fiber posts to root canals. J Appl Oral Sci 2015;23:436-41.
15. Kok D, Rosa RA, Barreto MS, Busanello FH, Santini MF, Pereira JR, et al. Penetrability of AH plus and MTA fillapex after endodontic treatment and retreatment: A confocal laser scanning microscopy study. Microsc Res Tech 2014;77:467-71.
16. Dornelles-Morgental R, Guerreiro-Tanomaru JM, de Faria-Júnior NB, Hungaro-Duarte MA, Kuga MC, Tanomaru-Filho M. Antibacterial efficacy of endodontic irrigating solutions and their combinations in root canals contaminated with Enterococcus faecalis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:396-400.
17. Chassot AL, Poisi MI, Samuel SM. In vivo and in vitro evaluation of efficacy of peracetic acid disinfectant for decontamination of acrylic resins. Braz Dent J 2006;17:117-21.
18. Magro MG, Kuga MC, Aranda-Garcia AJ, Victorino KR, Chávez-Andrade GM, Faria G, et al. Effectiveness of several solutions to prevent the formation of precipitate due to the interaction between sodium hypochlorite and chlorhexidine and its effect on bond strength of an epoxy-based sealer. Int Endod J 2015;48:478-83.
19. Daghustani M, Alhammadi A, Merdad K, Ohlin J, Erhardt F, Ahlquist M. Comparison between high concentration EDTA (24%) and low concentration EDTA (3%) with surfactant upon removal of smear layer after rotary instrumentation: A SEM study. Swed Dent J 2011;35:9-15.
20. Haralur SB, Al Faifi AH, Al-Qahtani SS. Influence of smear layer treatment on resistance to root fracture in tooth restored with epoxy fiber post. J Indian Prosthodont Soc 2014;14:156-60.
21. Saker S, Özcan M. Retentive strength of fiber-reinforced composite posts with composite resin cores: Effect of remaining coronal structure and root canal dentin conditioning protocols. J Prosthet Dent 2015;114:856-61.
22. Cecchin D, de Almeida JF, Gomes BP, Zaia AA, Ferraz CC. Influence of chlorhexidine and ethanol on the bond strength and durability of the adhesion of the fiber posts to root dentin using a total etching adhesive system. J Endod 2011;37:1310-5.
23. Bitter K, Aschendorff L, Neumann K, Blunck U, Sterzenbach G. Do chlorhexidine and ethanol improve bond strength and durability of adhesion of fiber posts inside the root canal? Clin Oral Investig 2014;18:927-34.
24. Lottanti S, Gautschi H, Sener B, Zehnder M. Effects of ethylenediaminetetraacetic, etidronic and peracetic acid irrigation on human root dentine and the smear layer. Int Endod J 2009;42:335-43.
25. De-Deus G, Souza EM, Marins JR, Reis C, Paciornik S, Zehnder M. Smear layer dissolution by peracetic acid of low concentration. Int Endod J 2011;44:485-90.
26. Kuga MC, Gouveia-Jorge É, Tanomaru-Filho M, Guerreiro-Tanomaru JM, Bonetti-Filho I, Faria G. Penetration into dentin of sodium hypochlorite associated with acid solutions. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:396-400.
27. Ordinola-Zapata R, Bramante CM, Garcia RB, de Andrade FB, Bernardineli N, de Moraes IG, et al. The antimicrobial effect of new and conventional endodontic irrigants on intra-orally infected dentin. Acta Odontol Scand 2013;71:424-31.
28. Arias-Moliz MT, Ordinola-Zapata R, Baca P, Ruiz-Linares M, García García E, Hungaro Duarte MA, et al. Antimicrobial activity of chlorhexidine, peracetic acid and sodium hypochlorite/etidronate irrigant solutions against Enterococcus faecalis biofilms. Int Endod J 2015;48:1188-93.
29. Gaddala N, Veeramachineni C, Tummala M. Effect of peracetic acid as a final rinse on push out bond strength of root canal sealers to root dentin. J Clin Diagn Res 2015;9:ZC75-7.
30. Elnaghy AM. Effect of QMix irrigant on bond strength of glass fiber posts to root dentine. Int Endod J 2014;47:280-9.
31. Scelza MF, Antoniazzi JH, Scelza P. Efficacy of final irrigation-a scanning electron microscopic evaluation. J Endod 2000;26:355-8.
32. Roeder RS, Lenz J, Tarne P, Gebel J, Exner M, Szewzyk U. Long-term effects of disinfectants on the community composition of drinking water biofilms. Int J Hyg Environ Health 2010;213:183-9.
33. Pereira JR, da Rosa RA, do Valle AL, Ghizoni JS, Só MV, Shiratori FK. The influence of different cements on the pull-out bond strength of fiber posts. J Prosthet Dent 2014;112:59-63.
34. Pereira JR, Rosa RA, Só MV, Afonso D, Kuga MC, Honório HM, et al. Push-out bond strength of fiber posts to root dentin using glass ionomer and resin modified glass ionomer cements. J Appl Oral Sci 2014;22:390-6.
35. Pereira JR, Lins do Valle A, Ghizoni JS, Lorenzoni FC, Ramos MB, Dos Reis Só MV. Push-out bond strengths of different dental cements used to cement glass fiber posts. J Prosthet Dent 2013;110:134-40.
36. Pereira JR, Valle AL, Ghizoni JS, Só MV, Ramos MB, Lorenzoni FC. Evaluation of push-out bond strength of four luting agents and SEM observation of the dentine/fiberglass bond interface. Int Endod J 2013;46:982-92.
37. Lipski M, Mrozek J, Droździk A. Influence of water cooling on root surface temperature generated during post space preparation. J Endod 2010;36:713-6.
38. Aranda-Garcia AJ, Kuga MC, Vitorino KR, Chávez-Andrade GM, Duarte MA, Bonetti-Filho I, et al. Effect of the root canal final rinse protocols on the debris and smear layer removal and on the push-out strength of an epoxy-based sealer. Microsc Res Tech 2013;76:533-7.
39. Arslan H, Ayrancı LB, Karatas E, Topçuoğlu HS, Yavuz MS, Kesim B. Effect of agitation of EDTA with 808-nanometer diode laser on removal of smear layer. J Endod 2013;39:1589-92.

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