# THE EFFECTS OF SURFACE TREATMENTS ON ROOT DENTIN ANALYZING MICROLEAKAGE OF ENDODONTICALLY TREATED TEETH RESTORED WITH FIBER POSTS

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**ABSTRACT**

**Aim:** The coronal seal is the main factor for the success of root canal treatment. This study was aimed to investigate the effects of different surface treatments of root dentin on coronal microleakage of endodontically treated teeth restored with the use of fiber posts.

**Materials & Method:** In this in vitro study, 72 single-canal mandibular premolars were selected and their crowns were removed at CEJ. After root canal treatment and preparation of the root canal space, a #3Peeso reamer was used to prepare a post space up to a depth of 9 mm in each root canal. The samples were randomly divided into 6 groups. The root canal space of samples in each group was irrigated with distilled water, NaOCl, EDTA, NaOCl + EDTA, phosphoric acid and NaOCl + ascorbic acid, respectively. The #1 fiber post was cemented into the root canal dentin. The samples were subjected to thermo-cycled for 1500 cycles at 5°C and 55°C with a **dwell time** of 60 seconds. Subsequently, all the samples were immersed in methylene blue. They were demineralized and cleared. The dye penetration depth was measured in μm from the beginning of the root canal under the post up to the depth of complete penetration of dye at post–dentin interface under a stereomicroscope at ×30. Data were analyzed wit SPSS 20, using one-way ANOVA and post hoc Tukey tests

**Results:** There was significant differences in microleakage between the study groups (One-way ANOVA,P<0.001). Ascorbic acid with NaOCl showed a significantly less microleakage in μm (1585±587.9), followed by distilled water (7777±4284), EDTA (4900±1523) and EDTA (3794±1197) in ascending order.

**Conclusion:** Ascorbic acid with NaOCl for the irrigation of root canal sprepared for post placement showed minimum microleakage.

**Key words:** Dentin surface treatment, fiber post, microleakage.

## Introduction

Endodontically treated teeth are structurally different from vital un-restored teeth and require special restorative treatments.[1,2] The principal changes in such teeth are lack of tooth structure, alterations to physical characteristics and altered esthetic properties.[3] All these changes result in an increased tendency for fracture and a decrease in the translucency of non-vital teeth.[2,3] Restoration of endodontically treated teeth is carried out to protect the remaining tooth structure against caries, to prevent re-infection of root canal system and to replace the lost tooth structure.[1] At the time of facing with the difficult task of restoring an endodontically treated tooth, the dentist should first decide whether it is necessary to place a post or not.[1,2]

A post is a restorative material which is placed within the root canal of a compromised tooth and provides extra retention for the core and the coronal restoration. The post is bonded or cemented within root canal and is extended coronally in order to support the core. A post is placed in order to provide retention for the core and the crown; it also prevents coronal micro-leakage and the resultant contamination.[2,3] A core is a restorative material which is placed in the coronal areas of a tooth and replaces the lost coronal structure of a tooth due to caries and fracture and retains the final restoration.[1]

An ideal post should minimize the stresses exerted on teeth, it should be easily removed if endodontic retreatment is necessary, and its tensile coefficient should be similar to that of dentin. In metallic posts, the odds of root fracture are high due to their higher tensile coefficients.[3] Due to the greater esthetic needs and development of ceramic crowns, the use of non-metallic posts has increased recently.[4,5] Esthetic posts exhibit good mechanical properties in addition to their esthetic appearance, justifying their clinical use. FRCs (fiber-reinforced composite posts) are a group of non-metallic posts and their structure basically consists of a large number of fibers with no specific direction, which have been dispersed in a polymer matrix; these fibers reinforce the structure of post and conduct the light.[4]

Restoration of endodontically treated teeth is not always successful. It has been reported that the majority of failures in the restorations of these teeth occur due to inefficient restorative treatments of these teeth, periodontal diseases, ineffective root canal treatment and microleakage around the restoration.[2]

Microleakage is an important factor with the use of posts and can affect the initiation of recurrent caries, the longevity of restoration and post and finally the failure of endodontic treatment. Clinically, microleakage occurs due to the fatigue resulting from dynamic stresses and formation of microcracks.[3-5] Various factors affect microleakage, including surface roughness ofthe post, solubility of the cement, the bond strength between post and tooth structure, and dentin permeability.[3,6]

If microleakage occurs after root canal treatment, the pulp chamber might be re-infected, which might result in the failure of endodontic treatment.[1,3] Microleakage might occur after post space preparation by the endodontist and before restoration by the restorative dentist.[3] To decrease the microleakage, it is possible to place a temporarily bonded restorative material at the root canal orifice or the cotton pellet impregnated within the root canal with a disinfecting agent.[1] During post space preparation, the drill creates a new smear layer, which changes into a plastic form due to the heat produced as a result of the friction of drill. Complete elimination of smear layer, which consists of microorganisms, destroyed infected dentin and the remnants of sealer within the root canal, possibly interfering with the polymerization of resin luting agents, is necessary for bonding the post using a resin.[3,4,6] Some chemical agents such as NaOCl, $H_2O_2$, EDTA, chlorhexidine gluconate, citric acid (15%, 20% and 50%) or ortho-phosphoric acid and their derivatives are necessary to increase the micromechanical retention of cement by eliminating the smear layer.[3,5] As a result, the cement can penetrate into the dentinal tubules. The remaining smear layer can interfere with bonding the post with root dentin, increasing the odds of microleakage at post–dentin interface.[7]

In a study by Mao *et al*.[8] irrigation using EDTA 17% with NaOCl 5.25% after post space preparation effectively removed the smear layer and increased the patency of dentinal tubule orifices, resulting in effective penetration of the adhesive resin into the dentinal tubules and the fibrillar structure of collagen.

Zheng *et al*.[9] evaluated the effect of different irrigation solutions and cements on the coronal microleakage of cast posts and cores and reported that a combination of NaOCl and EDTA resulted in greater amount of microleakage compared to a combination of $H_2O_2$ with physiologic serum and compared to when no irrigation solution was used.

Akgun *et al*.[10] reported that using NaOCl alone resulted in greater amount of microleakage compared to using NaOCl with sodium ascorbate in Class II composite resin restorations.

Morgan *et al*.[11] showed that an increase in the length of posts resulted in decreased polymerization and increased microleakage in the post depth.

A review of the literature showed that up to now, no studies have been carried out on the effects of chemical irrigants (surface treatments) on microleakage between post and dentin. Therefore, present study was performed to evaluate the effect of different treatments of root dentin surface on root microleakage of endodontically treated teeth restored with fiber posts.

**Materials and Method**

In the present in vitro study, 72 single-canal mandibular premolar teeth, with an identical size and root form, extracted for orthodontic reasons, were selected. The teeth had no caries and cracks and had no previous root canals treatment.

All the samples were stored in 0.2% thymol solution. The tooth crowns were removed at CEJ with a diamond saw (Kuppa Dental, Germany) at low speed to leave a root with at least 14 mm length. Then the root canals were filled and flared with hand K-files (Dentsply Company, United Kingdom) using step-back technique and obturated with gutta-percha (Meta Biomed, Korea) and AH26 sealer (Dentsply Company, USA) using lateral compaction technique. Then the teeth were incubated (Behdad, Iran) at 37°C and relative humidity of 100% for 24 hours.

Subsequently, 24 hours after root canal obturation, a #3 Peeso reamer (Mani, Japan) was used to prepare a post space up to a depth of 9 mm. Then a #3 specific drill of fiber post (Largo Drill) (Angelus, Brazil) was used to prepare the post space and the samples were randomly divided into 6 groups. [Table 1][7]

| Groups | Irrigation Solution | Manufacturer | Duration of Irrigation |
|---|---|---|---|
| 1 | Distilled Water (Control) | Caspian, Iran | 60 secs. |
| 2 | 5% NaOCl | Pakroo, Iran | 15 secs. |
| 3 | EDTA | Sina, Iran | 60 secs. |
| 4 | 5% NaoCl + EDTA | Pakroo, Iran Sina, Iran | NaOCl for 15 secs., followed by EDTA for 60 secs. |
| 5 | 37% Phophoric Acid | Ultradent, USA | 15 secs. |
| 6 | 5% NaoCl + 10% Ascorbic Acid | Pakroo, Iran Razi, Iran | NaOCl for 15 secs., followed by Ascorbic Acid for 15 secs. |

*Table 1: The Study Groups.*

Then, a #1 fiber post (Referepost; Angelus, Brazil), measuring 1.1 mm in diameter, was cemented with Panavia F2:0 cement (Kuraray, Japan) based on manufacturer's instructions. After cementation of the post, each root placed under a radiographic examination was evaluated in terms of buccolingual and mesiodistal aspects with the use of an Espeed radiographic film (Dentus, Belgium) and paralleling technique and the correct placement of post and the presence or absence of voids within the cement..

The samples were stored at 37°C and relative humidity of 100% for 48 hours. Then the samples were dried and their external surfaces were coated with two layer of nail varnish up to 1 mm from the interface. Then the samples were placed under 1500-round thermo cycling procedure at 5–55°C with a dwell time of 60 seconds and a transfer time of 12 seconds.

The samples were immersed in methylene blue at pH of 7.6 at ambient temperature for 72 hours. Then they were rinsed in water and dried, followed by immersion in 5% nitric acid for 6 days for demineralization so that the samples would assume an elastic state. In such a condition, a 30-guage needle would easily pass through a non-critical area of the tooth. In the next stage, the samples were immersed in 70%, 95% and 100% ethyl alcohol for 24 hours for dehydration. Then the samples were cleaned and placed in Petri dishes containing methyl salicylate for clearing. First, images were taken under a stereomicroscope, followed by measurement of the dye penetration depth in µm from the root canal beginning under the post up to the complete dye penetration depth at the post–dentin interface at ×30.

Data was analyzed by SPSS 20, using one-way ANOVA and post hoc Tukey tests ($\alpha = 0.05$).

**Results**

There was a significant difference between the studied groups in microleakage (One-way ANOVA , $P<0.001$). [Table 2]

| Groups | Mean $\pm$ SD |
|---|---|
| Ascorbic Acid in Association with NaOCl | 1585 $\pm$ 587.9 |
| Phosphoric Acid | 2560 $\pm$ 859.1 |
| EDTA | 4900 $\pm$ 1523 |
| NaOCl | 2683 $\pm$ 953.8 |
| NaOCl + EDTA | 3798 $\pm$ 1197 |
| Control | 7777 $\pm$ 4284 |
| Total | 3863 $\pm$ 2790 |

*Table 2: The means and standard deviations of microleakage in µm in the study group.*

A combination of ascorbic acid and NaOCl resulted in minimum microleakage, which was statistically significant, and the differences between it and phosphoric acid and NaOCl were at significance threshold.

The distilled water group exhibited the maximum microleakage, which was statistically significant; however, the differences between it and the EDTA and NaOCl + EDTA groups were not significant.

**Discussion**

The smear layer is produced after instrumentation of the root canals with manual and rotary instruments. It consists of debris, dentin remnants, and organic and inorganic materials such as remnants of odontoblasts, microorganisms and necrotic materials.[12] Such debris and pulp remnants create a barrier to the surface of dentin, decreasing the adhesive bonding of resin cement specifically used for bonding the fiber posts to the root canal walls.[13] Some studies have suggested that the use of NaOCl and phosphoric acid or the use of a chelating agent can effectively remove the smear layer and improve retention of the post.[14,15] Therefore, in present study, the effect of using different irrigation solutions before post placement was evaluated on the microleakage of endodontically treated teeth reinforced with fiber posts.

The results of present study showed that using ascorbic acid with NaOCl resulted in the least microleakage, followed by phosphoric acid and NaOCl groups alone, which exhibited less microleakage compared to the other groups and the difference between these two groups and the ascorbic acid/NaOCl group was at significance threshold, which might have become significant with a larger sample size. The reason for lower microleakage in the phosphoric acid/NaOCl group is that it has been shown that phosphoric acid and NaOCl have a great role in removing the smear layer; in this context, NaOCl removes the organic component and phosphoric acid removes the inorganic component of the smear layer, increasing penetration of the bonding agent into dentinal tubules and decreasing microleakage.[14,15] Since NaOCl has deprotenizing and oxidative effects on the root dentin and results in the production of free oxygen, it produces an oxygen-rich layer on the surface of dentin, resulting in a decrease in bond strength and an increase in microleakage. Elimination of this oxygen-rich layer returns the bond strength to an optimal level. Using sodiumascorbate and/or 10% ascorbic acid has been recommended to eliminate this layer, to increase the bond strength and to decrease microleakage after the use of NaOCl.[16] Therefore, the results of present study showed the minimum amount of microleakage in the NaOCl/ascorbic acid group and they are consistent with the results of previous studies which have shown the effective role of ascorbic acid in removing the oxygen-rich layer and in decreasing microleakage.[16] On the other hand, the distilled water group exhibited significantly more microleakage, which was not significantly different from the EDTA and EDTA/NaOCl groups. A higher rate of microleakage in the distilled water group as a control group is normal because in addition to the productionof the smear layer with the use of hand and rotary instruments during root canal treatment, preparation of the post space creates a thick layer of smear layer consisting of debris and sealer/gutta-percha remnants, affecting the bonding of fiber post.[17] In addition, the friction of drill results in plasticizing the remnants of the sealer and gutta-percha, leading to a decrease in the penetration of bonding agent. On the other hand, the post space allows minimum penetration of the irrigation solution; therefore, achieving maximum retention of post requires a clean dentin surface after preparation of the post space, especially with the use of a resin cement. Therefore, considering the inability of distilled water to remove the smear layer, a higher rate of microleakage in this group seems to be logical.[18] However, in relation to the similarity of microleakage in the distilled water and EDTA groups, it has been shown that chelating agents such as EDTA are not easily removed from the root canal space by irrigation due to the presence of poly ethylene glycolin in their structure, interfering with the polymerization of resin compounds and decreasing the bond strength of resin to dentin.[16] In addition, it has been shown that EDTA, as a chelating agent, can demineralize root dentin and dissolve its calcium components,[19-22] and since Panavia primer contains functional monomers such as 10-MDP with a capacity to form a chemical bond with the calcium in tooth structure, dissolution of calcium compounds results in a decrease in the chemical bond and possibly in an increase in microleakage. On the other hand, it has been shown that NaOCl has the capacity to dissolve the organic components of collagen. Therefore, a combination of these two irrigation solutions results in a decrease in dentin hardness, removal of the smear layer[23] and an increase in the penetration of resin into dentin.[8]

In a study by Mao *et al*.[8] the effects of different irrigation solutions (17% EDTA with 5.25% NaOCl, 10% NaOCl and 0.9% NaOCl) were evaluated on cleaning root dentin and formation of resin tags after post space. The results showed that irrigation with 17% EDTA, followed by 5.25% NaOCl after post space preparation effectively removed the smear layer and increased the patency of dentinal tubule orifices, improving the penetration of the adhesive resin into dentinal tubules.

Zheng *et al*.[9] evaluated the effects of different irrigation solutions and cements on the coronal microleakage of cast posts and cores and reported that irrigation had a significant effect on microleakage; however, the cement type had no effect on microleakage. On the other hand, the results showed that a combination of NaOCl and EDTA resulted in greater microleakage compared to $H_2O_2$ with physiologic serum and compared to the situation in whichno irrigation was carried out.

The results of present study were different from those of Mao *et al*.[8] in present study, microleakage in the EDTA/NaOCl group was higher. Such a discrepancy between the results might be attributed to the production of free oxygen by NaOCl, which decreases the bond strength and increases microleakage; EDTA cannot remove this oxygen-rich layer.[16] On the other hand, since EDTA can demineralize root dentin and dissolve its calcium compounds, as a chelating agent, it results in a decrease in the chemical bond and possibly in an increase in microleakage, especially with the use of resin cements.[19,22] On the other hand, the results of present study in relation to an increase in the amount of coronal microleakage with the use of a combination of NaOCl and EDTA are consistent with those of a study by Zheng *et al*..[9] Therefore, it can be claimed that despite the belief that a combination of NaOCl and EDTA results in more effective removal of smear layer, the amount of microleakage was higher in such a situation compared to when NaOCl was used alone, with no significant difference from the control and EDTA groups. Therefore, it can be pointed out that although a combination of NaOCl and EDTA increases the penetration of adhesive resin into dentinal tubules by effectively removing the smear layer,[8] demineralization of dentin by EDTA changes the properties of dentin and affects the bond strength,[19,22] increasing microleakage.[9]

In a study by Morris *et al*,[16] the bond strength of resin material to dentin decreased after the application of NaOCl and production of free oxygen; however, after the application of ascorbic acid it returned to a favorable level. In addition, Akgun *et al*.[10] compared the effects of irrigation solutions on the microleakage of Class II composite resin restorations and reported that using NaOCl alone resulted in higher rate of microleakage compared to the use of NaOCl and sodium ascorbate together. Therefore, since sodium ascorbate is derived from a combination of ascorbic acid and sodium, the results of present study in relation to the effect of ascorbic acid on decreasing microleakage are consistent with those of a study by Akgun *et al*..[10] Therefore, it can be concluded that using a combination of ascorbic acid and NaOCl, as an irrigation solution, or a combination of sodium ascorbate and NaOCl, can decrease coronal microleakage, which might be attributed to the elimination of the oxygen-rich layer created by NaOCl, after the use of ascorbic acid, and an increase in the bond strength of the resin material to dentin, resulting in a decrease in microleakage.[16]

Considering the limitations of present study, in order to more accurately evaluate microleakage, it is suggested that the seal of dentinal tubules are evaluated by SEM because they are important factors used to reduce the microleakage.

**Conclusion**

Use of ascorbic acid with NaOCl for irrigation of the root canals for post placement may resulted in minimum microleakage, whiley the use of distilled water, EDTA and a combination of EDTA and NaOCl showed higher rate of microleakage, respectively.

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