Effect of Smear Layer Removal After Post Space Preparation on the Apical Seal of Endodontically Treated Teeth

Endodontik Tedavili Dişlerde Post Boşluğu Hazırlandıktan Sonra Smear Tabakasının Uzaklaştırılmasının Apikal Sızıntıya Etkisi

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ABSTRACT Objective: The aim of this study was to evaluate the effect of smear layer removal using ethylenediaminetetraacetic acid (EDTA), citric acid, or maleic acid after post space preparation on the apical seal using a fluid filtration study design. **Material and Methods:** In this study, 40 freshly extracted, single-rooted anterior human teeth were used. Root canals were prepared chemomechanically and all canals were obturated with AH26 sealer and gutta-percha with the cold lateral compaction technique. After post space preparation, they were divided into 4 groups according to the irrigation solutions used for debridement: (1) EDTA group, 17% EDTA; (2) maleic acid group, 7% maleic acid; (3) citric acid group, 10% citric acid; and (4) control group, distilled water. After finishing the post space treatments, post spaces were dried with paper points. Fiber posts were cemented with Panavia F 2.0. The computerized fluid filtration method was used for evaluation of apical microleakage. Data were analyzed with one-way ANOVA followed by Tamhane's T2 test. **Results:** The least leakage was recorded in the maleic acid group, followed by the EDTA group ($p<0.001$). However, there was no significant difference between the maleic acid and EDTA groups ($p=0.136$). The maximum leakage was observed in the control group. **Conclusion:** Final irrigation with EDTA or maleic acid after post space preparation had a positive effect on apical sealing ability.

Key Words: Post and core technique; smear layer

ÖZET Amaç: Bu çalışmanın amacı post boşluğu hazırlandıktan sonra oluşan smear tabakasının etilendiamintetra asetik asit (EDTA), maleik asit veya sitrik asit ile uzaklaştırılmasının apikal sızıntı üzerine etkisinin bilgisayarlı sıvı filtrasyon yöntemi ile incelenmesidir. **Gereç ve Yöntemler:** Bu çalışmada 40 adet yeni çekilmiş, tek köklü, insan üst kesici dişleri kullanılmıştır. Kök kanalları kemomekanik olarak prepare edilmiş ve AH 26 kanal patı ve gütta-perka ile soğuk lateral kondensasyon tekniği ile doldurulmuştur. Post boşlukları hazırlandıktan sonra dişler debridman için kullanılan irrigasyon solusyonlarına göre dört gruba ayrılmıştır: (1) EDTA grubu, %17 EDTA; (2) maleik asit grubu, %7 maleik asit; (3) sitrik asit grubu, %10 sitrik asit; ve (4) kontrol grubu, distile su. Post boşluklarının hazırlamasından sonra kök kanalları paper point ile kurulanmıştır. Fiber postlar Panavia F 2.0 kullanılarak simante edilmiştir. Apikal sızdırmazlığın incelenmesinde bilgisayarlı sıvı filtrasyon yöntemi kullanılmıştır. Elde edilen veriler one-way ANOVA ve Tamhane's T2 testi ile incelenmiştir. **Bulgular:** En az apikal sızıntı maleik asit grubunda elde edilmiştir. Maleik asit grubunu EDTA grubu takip etmektedir ($p<0,001$). EDTA ve maleik asit grupları arasında ise istatistiksel olarak anlamlı farklılık yoktur ($p=0,136$). En fazla apikal sızıntı değerleri ise kontrol grubunda gözlenmiştir. **Sonuç:** Post boşluğu hazırlandıktan sonra EDTA veya maleik asit yıkama solüsyonu ile smear tabakasının uzaklaştırılmasının apikal sızdırmazlığın sağlanmasına pozitif etkisi vardır.

Anahtar Kelimeler: Kök çivisi tekniği; smear tabakası

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In recent years, fiber posts have been used to restore endodontically treated teeth with an excessive loss of dental structure. Since fiber posts have an elastic modulus similar to that of dentin, chewing loads along

the radicular walls are better distributed and the risk of fracture is reduced.[1] Effective and durable bonding between post, dentin, and adhesive resin luting cements is essential for the longevity of restorations. Adhesive resin luting cements, which have an elastic modulus in the same range as that of both fiber posts and dentin, provide better adaptation to root canal walls and reduce microleakage by creating a homogeneous monoblock structure with fiber posts. Current studies have indicated that bonding to root canal dentin is affected by many factors such as endodontic irrigants and sealers, limited moisture control, unfavorable C-factor, and the presence of a thick smear layer, which is produced during the preparation of a post space.[2]

Removal of the smear layer has been a subject of controversy for several years but is necessary for increasing the retention of adhesive luting cements in dentinal tubules.[3,4] If the sealing ability of adhesive systems used to lute post-core materials is inadequate, subsequent microleakage may cause failure of endodontic treatments.[5] It is difficult to remove the smear layer in the root canal with regular water irrigation because of the narrow and deep circumstance of the post space, especially in its apical area. Therefore, the post space needs to be effectively cleaned before fiber post cementation.[6] Few studies have evaluated the efficacy of smear layer and debris removal after post space preparation using chemical irrigation solutions, such as ethylenediaminetetraacetic acid (EDTA), phosphoric acid, and sodium hypochlorite (NaOCl), in combination with ultrasonic activation or alone.[4,6-8] Prabhu et al. showed that 5% and 7% maleic acid can be used as an alternative to the routinely used 17% EDTA.[9] Recently, it was reported that final irrigation with 7% maleic acid is more efficient than 17% EDTA in the removal of smear layer from the apical third of the root canal system.[10] To date, no study has investigated the effect of smear layer removal after post space preparation on the apical seal. The aim of this study was to evaluate the effect of smear layer removal using EDTA, citric acid, or maleic acid after post space preparation on the apical seal using a fluid filtration study design. The null hypothesis tested was that smear layer removal after post space preparation does not affect the apical seal.

MATERIAL AND METHODS

SPECIMEN PREPARATION

Ethical clearance was obtained from the Ethical Committee (2012/252-942) of Istanbul University, Istanbul, Turkey. Forty extracted sound anterior human teeth of similar length obtained from 40- to 60-year-old patients with periodontal diseases were used in this study. Teeth were stored in 0.1% thymol solution at 4°C until use. All the endodontic treatments were performed by the same operator. Standard access cavities were prepared, and the working length was established by inserting a size 10 K-file (Mani Inc., Tochigi Ken, Japan) into each root canal until it was just visible at the apical foramen and then subtracting 1 mm from this point. Chemomechanical preparation was performed with a step-back technique using K-files (Mani Inc.). Apical enlargement was performed to ISO size 60. Irrigation was carried out with 1 mL of 2.5% NaOCl solution (Norateks Chemical Industry, Istanbul, Turkey) after each instrument change. All canals were obturated with AH26 sealer (Dentsply; DeTrey, Konstanz, Germany) and gutta-percha with the cold lateral compaction technique. After obturation, excess gutta-percha was removed with Gutta Cut (VDW, Munich, Germany) and vertically compacted with a plugger. The teeth were then coronally sealed with glass-ionomer cement (Fuji II; GC, Tokyo, Japan) and stored in a humidor at 37°C for 7 days to complete setting of the sealer.

The anatomic crown of each tooth was cut off 2 mm incisally from the cementoenamel junction. The gutta-percha was removed using a hot plugger, and the post space was prepared with lowspeed post drills (DT; Bisco Inc., Schaumburg, IL, USA), leaving at least 4-5 mm of gutta-percha to preserve the apical seal. Each drill was used 5 times. The remaining root canal filling was then vertically condensed using a cold plugger. After post space preparation, all teeth were randomly divided into 4

groups according to the irrigation solutions used for debridement: (1) EDTA group, 3 mL of 17% EDTA (Norateks Chemical Industry) for 1 minute followed by 10 mL of distilled water; (2) maleic acid group, 3 mL of 7% maleic acid (Norateks Chemical Industry) for 1 minute followed by 10 mL of distilled water; (3) citric acid group, 3 mL of 10% citric acid (Norateks Chemical Industry) for 1 minute followed by 10 mL of distilled water; (4) control group, 10 mL of distilled water. All the irrigation solutions were introduced into the post space using a 5 mL disposable plastic syringe (Ultradent Products Inc., South Jordan, UT, USA) with a 30-gauge side-vented needle (KerrHawe Irrigation Probe; KerrHawe SA, Biggio, Switzerland). After finishing the post space treatments, post spaces were dried with paper points.

Fiber posts (DT Light Post #2; VDW) were cemented into canals with Panavia F 2.0 (Kuraray Medical Inc., Tokyo, Japan) according to the manufacturer's instructions.

EVALUATION OF APICAL LEAKAGE

In this in vitro study, apical leakage was measured at 7 days using the computerized fluid filtration method described by Orucoglu et al.[11] Using this system, all the operations were controlled with PC-compatible software (Fluid Filtration'03, Konya, Turkey) during the experiment. The pressure (120 kPa) was maintained at a constant level throughout the experiment by means of a digital air pressure regulator (DP-42 Digital pressure and vacuum sensors Red LED display; Sunx Sensors, USA) added to the pressure tank. A 5 minute pressurization preload of the system was completed before obtaining readings. Measurements of fluid movement were automatically obtained at 2 minute intervals during an 8 minute period for each sample by means of PC-compatible software. Leakage quantity was expressed as $\mu L \cdot cmH_2O^{-1} \cdot min^{-1}$.

To compare the effects of the different irrigation protocols after post space preparation on apical microleakage, one-way ANOVA followed by Tamhane's T2 test was used. $p<0.05$ was considered statistically significant.

RESULTS

The least leakage was recorded in the maleic acid group, followed by the EDTA group. The maximum leakage was observed in the control group ($p<0.001$) (Table 1). Statistical analysis revealed that maleic acid and EDTA achieved better sealing than did citric acid and control treatment. There was no significant difference between the maleic acid and EDTA groups ($p=0.136$).

DISCUSSION

Apical sealing ability is influenced by many factors such as the method of gutta-percha removal, the amount of remaining filling material, and the timing of post space preparation.[12-15] Various findings have been reported on the effects of time of post space preparation and amount of remaining gutta-percha on the apical seal. It has been shown that when the post space is prepared immediately after filling, the root canal filling can be removed without causing micro-fractures of the sealer and movements of the gutta-percha, because setting of the sealer is not completed.[15] The classic literature generally states that a minimum of 3–6 mm of gutta-percha should be retained in the apical portion of the root to maintain an adequate seal.[14] Another factor influencing the apical seal after post space preparation is the technique used for removing gutta-percha and sealer. Some authors have concluded that in comparison with mechanical and thermal techniques, chemical removal results in more microleakage because it is difficult to control the depth of softening of the gutta-percha.[12] Although mechanical removal of gutta-percha is efficient and probably the most commonly used

TABLE 1: Apical microleakage values in $\mu L.cmH_2O\text{-}1.min^{-1}x10^{-4}$.

Group (n=10 per group)	Mean±Standard Deviation
1. EDTA	2.71±1.01[a]
2. Maleic acid	2.55±1.67[a]
3. Citric acid	3.43±1.43[b]
4. Control	4.08±2.02[b]

Groups identified by different superscript letters were significantly different (p<0.05).

technique, some authors have found significantly greater leakage after removal of gutta-percha with Gates Glidden drills than after removal with heated pluggers.[13]

Self-adhesive resin cements have been recommended for fiber post luting because of the advantage that no pretreatment of dental and restorative substrates is required. However, removal of the smear layer with acidic solutions has been proposed to enhance the interaction between the cement and dentin, because the presence of a thick "secondary" smear layer in the post space negatively affects the dentin demineralization and penetration potential of self-adhesive resin cements.[2,16] The hybridized smear layer produced by self-etching adhesives is a weak area in the bonding interface. Therefore, the dentin surface of the post space should be effectively cleaned before fiber post cementation, allowing the infiltration of self-etching adhesives.[6,17]

Removal of the smear layer is a controversial issue in the endodontic community. In a recent systematic review, Shahravan et al. evaluated the articles published on the effect of smear layer removal on the sealing ability of canal obturation.[18] It was concluded that smear layer removal improves the fluid-tight seal of the root canal system, whereas other factors, such as the obturation technique or sealer used, did not produce significant effects. Therefore, removal of the smear layer is important to achieve effective dentin bonding and thereby the longevity of root canal treatments.[8] Different chelating agents, like EDTA, citric acid, maleic acid, and phosphoric acid, have been used for removing the smear layer.[10,19] The combined application of EDTA and NaOCl is commonly used as an effective method for smear layer removal.[20] EDTA is a chelating agent, and it is effective at a neutral pH. The efficacy of EDTA decreases over time because of the resultant decrease in pH. Maleic acid is a weak acid, and it may cause a mineral gradient in the exposed dentine rather than the complete surface demineralization observed with strong acids such as phosphoric acid or strong chelators such as EDTA.[21] Recently, Ballal et al. reported that final irrigation with maleic acid is more efficient than irrigation with 17% EDTA for the removal of smear layer from the apical third of the root canal system.[10] This may be explained by the higher surface tension of 17% EDTA compared to that of maleic acid and the sclerosed dentin structure of the apical root canal system.

In this study, maximum apical leakage was seen in the control group treated with distilled water. This result, in accordance with the findings of previous studies, shows that distilled water does not have an effect on smear layer removal.[10,22] The results of the current study revealed that 7% maleic acid and 17% EDTA had better sealing efficacy than did citric acid and control treatment; however, there was no significant difference between maleic acid and EDTA. This finding is in contrast to the findings of other studies comparing the influence of 7% maleic acid and 17% EDTA as final irrigants on apical sealing ability; these studies reported that the sealing ability of maleic acid was better than that of EDTA.[22,23] This might be explained by the different structure of the smear layer that is created during post space preparation. The drills used for post space preparation produce a new smear layer rich in sealer and gutta-percha remnants plasticized by bur friction heat. Dentin tubules are occluded by plugs of gutta-percha and/or sealer remnants. Therefore, etching treatment with 35% phosphoric acid followed by water rinsing does not clean the post space completely.[4,7] Serafino et al. reported that post space treatment by means of ultrasound agitation followed by etching with phosphoric acid seemed more efficient than etching alone for the removal of smear layer and debris.[24] However, Gu et al. reported that additional ultrasonic irrigation did not significantly improve post space smear layer removal.[6] Smear layer removal from the post space using a combination of EDTA and NaOCl was recommended to facilitate the penetration of resin tags into dentinal tubules and to improve bond strength.[25]

Microleakage has been evaluated using various techniques, such as radioactive isotope tests, bacteria or bacterial metabolite leakage tests, the degree of penetration of a dye, and glucose penetration models.[23,26-29] In the present study, the computerized fluid filtration method was used because

it provides full quantitative volumetric data. In addition, the sensitivity of the system can be adjusted by altering the pressure used and the diameter of the measurement micropipette.[30]

CONCLUSIONS

Within the limitations of this study, we observed that irrigation with EDTA or maleic acid after post space preparation had a positive effect on apical sealing ability. Therefore, the null hypothesis that smear layer removal after post space preparation does not affect the apical seal was rejected. Further investigations should be performed to clean the post space more effectively in order to provide better bonding and to ensure the longevity of fiber post restorations.

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