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Araştırma/ Research Article

EFFECT OF SODIUM THIOSULFATE ON BOND STRENGTH AN EPOXY RESIN-BASED SEALER TO SODIUM HYPOCHLORIDE- AND CITRIC ACID- TREATED DENTIN

SODYUM TİYOSÜLFATIN EPOKSİ REZİN BAZLI BİR KANAL PATININ SODYUM HİPOKLORİT VE SİTRİK ASİT UYGULANMIŞ DENTİNE BAĞLANMA GÜCÜNE ETKİSİ

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ABSTRACT

Aim: The aim of this study was to evaluate the effect of sodium thiosulfate on the bond strength of an epoxy resin-based sealer to NaOCl- and citric acid-treated dentin.

Materials and Methods: Fifteen maxillary central incisors were selected. Three discs (1.0 ± 0.1 mm thick) were cut from the middle third of the roots. Two holes were prepared in the root dentin. All of the specimens were immersed in 5.25% NaOCl for 30 minutes, immersed in 10% citric acid for 1 minute and 5.25% NaOCl for 1 minute. The specimens were randomly distributed into 3 groups: group 1: control group (no irrigation); group 2: distilled water group (immersed in distilled water for 10 minutes); and group 3: sodium thiosulfate group (immersed in 5% sodium thiosulfate for 10 minutes). The holes were filled with an epoxy resin-based sealer. A push-out test was performed on each hole. The data were analyzed statistically.

Results: The bond strength of the specimens irrigated with sodium thiosulfate was higher than that of the control group ($P < 0.05$). However, there was no significant difference between the control and the distilled water groups ($P > 0.05$).

Conclusions: Within the limitations of the present study, it can be concluded that 5% sodium thiosulfate for 10 min increased the bond strength of the sealer to NaOCl- and citric acid-treated dentin.

Key Words: Antioxidant agent, bond strength**,** resin sealer, sodium hypochlorite, sodium thiosulfate

ÖZ

Amaç: Bu çalışmanın amacı sodyum tiyosülfatın, epoksi rezin bazlı bir kanal patının NaOCl ve sitrik asit uygulanmış dentine bağlanma kuvvetine etkisini değerlendirmektir.

Gereç ve Yöntem: On-beş maksiller santral kesici diş seçildi. Köklerin orta üçlüsünden üçer disk (1.0 ± 0.1 mm kalınlığında) kesildi. Kök dentinleri üzerinde ikişer adet boşluk hazırlandı. Tüm örnekler 30 dakika süreyle %5.25'lik NaOCl içinde, 1 dakika süreyle %10'luk sitrik asit içinde ve 1 dakika süreyle %5.25'lik NaOCl içinde bekletildi. Örnekler randomize olarak 3 gruba ayrıldı: grup 1: kontrol grubu: (irrigasyon yok); grup 2: distile su grubu (10 dakika süreyle distile su içinde bekletildi); ve grup 3: sodium tiyosülfat grubu (10 dakika süreyle %5'lik sodium tiyosülfat içinde bekletildi). Boşluklar epoksi rezin bazlı bir kanal patı ile dolduruldu. Her bir boşluğa push-out testi uygulandı. Veriler istatistiksel olarak analiz edildi.

Bulgular: Sodyum tiyosülfatla irrige edilen örneklerin bağlanma kuvveti kontrol grubundan daha yüksekti ($P < 0.05$). Fakat, kontrol ve distile su grupları arasında anlamlı farklılık yoktu ($P > 0.05$).

Sonuçlar: Çalışmanın sınırları dahilinde, 10 dakika süreyle %5'lik sodium tiyosülfatın, kanal patının NaOCl- ve sitrik asit-uygulanmış dentine bağlanma kuvvetini arttırdığı sonucuna varılabilir.

Anahtar Kelimeler: Antioksidan ajan, bağlanma kuvveti, rezin kanal patı, sodium hipoklorit, sodium tiyosülfat

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INTRODUCTION

Elimination of bacteria and their by-products from the root canal system is one of the goals of root canal therapy. Current endodontic treatment methods are insufficient with regard to complete elimination of microorganisms from root canals.[1, 2] Therefore, creating an apical seal with an obturating material and entombing residual bacteria are essential goals for successful endodontic treatment.[3] The inadequate sealing ability of obturating material can cause microleakage and this may result in failure of the endodontic treatment.[4-6]

Root canal irrigating solutions play an important role in chemo-mechanical preparation of the root canal system because they have antibacterial effects and they serve as lubricants during instrumentation.[7] However, they can change the structure of the dentin surface and influence the sealing ability and adhesion of root-filling materials.[8-10] In particular, sodium hypochlorite (NaOCl) degrades dentin by dissolving collagen.[11] Sodium hypochlorite is also an oxidizing agent that generates an oxygen-rich layer on dentin surfaces[12] that might prevent the penetration of sealer dentinal tubules.[13, 14]

Sodium thiosulfate is an antioxidant agent that has been used in medicine[15] and it has been reported that antioxidants can restore the resin composite-dentin bond strength to normal levels in teeth that have been treated with NaOCl.[16, 17] Although there were studies about composite resin-dentin bond strength,[18-20] there is no study about the effect of final irrigation with sodium thiosulfate on the bond strength of an epoxy resin-based sealer. Therefore, the aim of this study was to evaluate the effect of sodium thiosulfate on the bond strength of an epoxy resin–based sealer to NaOCl- and citric acid-treated dentin. The null hypothesis was that there would be no difference among the groups in terms of the push-out bond strength of the epoxy resin-based sealer.

MATERIALS AND METHODS

Fifteen maxillary central incisors with straight roots were selected from a collection of teeth that had been extracted for reasons unrelated to this study. Soft tissue and calculus were removed mechanically from the root surfaces with a periodontal scaler. Three discs (1.0 ± 0.1 mm thick) were cut from the middle third of the root, under continuous water irrigation, using a low-speed saw (ISOMET, Buhler Ltd. Lake Buff, NY, USA) with a diamond disc (Ø 102 mm, 0.3 mm; Buhler Ltd.). Forty-five dentin slices were produced following this protocol.

A 1-mm round tungsten carbide bur (Hager & Meisinger GmbH, Neuss, Germany) was used to drill two holes on the root dentin under water-cooling, perpendicular to the root slice (Figure 1). To simulate the exposure of dentin to NaOCl during root canal treatment, all of the specimens were immersed in 5.25% NaOCl for 30 minutes, then immersed in 10% citric acid for 1 minute and 5.25% NaOCl for 1 minute, to simulate clinical conditions. Then, the specimens were randomly distributed into 3 groups according to the irrigating protocol, as described below (n = 15; 30 holes per group):

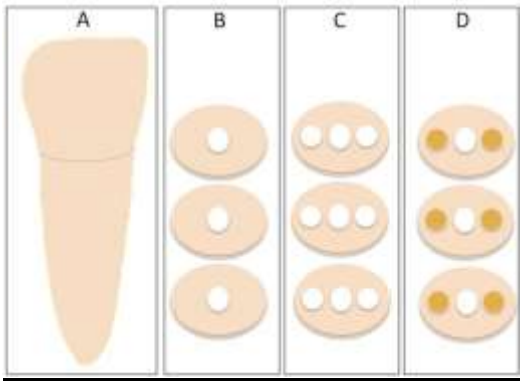

Figure 1. A schematic illustration of preparing of the specimens. (A) Maxillary central incisor were used, (B) Three discs were cut from the middle third of the root, (C) two holes were prepared on the root dentin, (D) the holes were filled with epoxy resin based sealer (after irrigation procedures).

Control group: No irrigation was performed.

Distiller water group: The specimens were immersed in distilled water for 10 minutes.

Sodium thiosulfate group: The specimens were immersed in 5% sodium thiosulfate for 10 minutes.

The holes were dried with paper points (Dentplus, Choonchong, Korea) and filled with epoxy resin based sealer (2Seal; VDW, Munich, Germany) with gentle vibration. The specimens were stored at 37 °C, in contact with sterile gauze moistened with phosphate-buffered saline solution for one week.

A 0.65-mm diameter plunger tip was used to dislocate the sealer in the apico-coronal direction

(Figure 2). Loading was performed using a universal testing machine (Instron, Canton, MA, USA) at a cross-head speed of 0.5 mm/min until debonding occurred. The load was recorded in newton (N) and the bonded interface area was calculated to obtain the megapascal (MPa) data.

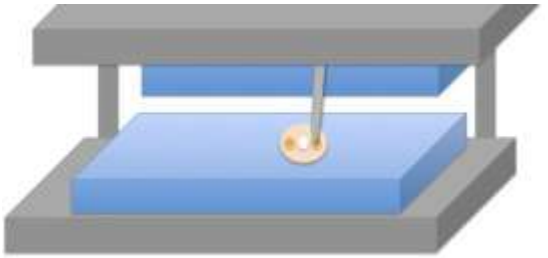

Figure 2. A schematic illustration of the push-out test.

The failure type of the sealer was determined with stereomicroscopic evaluation as adhesive failure (between the sealer and root dentin), cohesive fracture (within the sealer or root dentin) and mixed (a combination of cohesive and adhesive failures).[21, 22]

Statistical analyses were performed using IBM SPSS Statistics 20 software (IBM SPSS Inc., Chicago, IL, USA), and a level of 0.05 was considered statistically significant (confidence interval of 95%.). The data for bond strength were statistically examined using homogeneity of variance and Kolmogorov-Smirnov tests to determine whether the data were homogeneous and normally distributed. As the data were homogeneous (P > 0.05) and normally distributed (P > 0.05), the bond strength data was analyzed using one-way ANOVA (Analysis of Variance) and LSD (Least Significant Difference) tests. The data for failure type were analyzed using a chi-square test (P = 0.05).

RESULTS

Table 1 shows the mean and standard deviation of the push-out bond strength values (MPa) of the sealer to root dentin according to the groups. The bond strength of the specimens irrigated with sodium thiosulfate was higher than that of the control group (P < 0.05). However, there were no significant differences between the control and distilled water groups (P > 0.05).

The failure types were listed in Table 2. There were no significant differences in the failure type within the groups (P > 0.05). Adhesive failure between the resin sealer and dentin was the most frequent type of failure in all the groups.

Table 1. Mean push-out bond strength values for the groups. Different letters mean statistically significant differences between the groups.

Control group	Distilled water	Sodium thiosulfate
11.72 ± 4.44 [a]	12.13 ± 2.56 [ab]	13.65 ± 3.93 [b]

Table 2. Failure types according to the groups.

Failure type	Control group	Distilled water	Sodium thiosulfate	Total
Adhesive	18 (60%)	22 (73.3%)	20 (66.7%)	60 (66.7%)
Cohesive	9 (30%)	4 (13.3%)	5 (16.7%)	18 (20%)
Mixed	3 (10%)	4 (13.3%)	5 (16.7%)	12 (13.3%)
Total	30 (100%)	30 (100%)	30 (100%)	90 (100%)

DISCUSSION

According to the results of the present study, the control group had the lowest bond strength of sealer adhesive to root dentin among the groups. It might be explained by damage to the organic matrix from NaOCl, erosion from chelating agents[23] and also inhibition of the interfacial polymerization of adhesive materials.[18,24,25] Previous reports[18,24, 25] have evaluated the effect of antioxidants on the bond strength of various adhesive systems, mainly composite resins, applied to NaOCl-treated dentin. Although root dentin was exposed to NaOCl, there was no study evaluating the effect of final irrigation with an antioxidant agent on the bond strength of sealer to NaOCl/citric acid-treated dentin. Thus, the present study focused on the effect of sodium thiosulfate—an antioxidant—on the bond strength of sealer to NaOCl- and citric acid-treated dentin. According to the results, there were significant differences between the groups; therefore, the null hypothesis was rejected.

In the present study, an epoxy resin-based sealer was used after irrigation procedures, which can react with exposed amino groups in collagen to form covalent bonds between the resin and collagen when the epoxide ring opens.[26] However, irrigation with NaOCl, which is an oxidizing agent, can degrade the collagen and leave an oxygen-rich layer on the dentin

surface.[18, 25] The residual-free oxygen radicals can diffuse into the dentin, resulting in inhibition of bonding and decreasing the bond strength of the adhesive to root dentin. This oxygen-rich layer on dentin surfaces might also prevent the penetration of sealer into the dentinal tubules.[12-14] The present study's results indicated that use of an antioxidant (sodium thiosulfate) after NaOCl irrigation significantly increased the bond strength of sealer to root dentin. Although sodium thiosulfate had been used in microbiology studies to neutralize NaOCl,[27, 28] there is no study about its effect on the bond strength of sealers. Thus, an indirect comparison could be done with the findings of previous studies. Previously, Lai et al.[29] observed that following treatment with sodium ascorbate—an antioxidant agent—reduction in the bond strength of Single Bond or Excite to dentin was reversed. Similarly, Vongphan et al.[25] evaluated the microtensile bond strengths of etch and rinse adhesive systems to the pulpal chamber wall after treatment with various irrigants and found that the application of sodium ascorbate to NaOCl-treated dentin significantly improved the bond strength of adhesive systems. Moreover, Pimentel Correa et al.[18] evaluated the efficacy of sodium thiosulfate for restoring adhesion to pulp chamber dentin treated with NaOCl and EDTA, and found that the use of sodium thiosulfate can significantly increase the bond strength of composite resin to NaOCl- and citric acid-treated dentin, allowing adhesive restorations to be immediately applied after endodontic treatment. These results were consistent with the findings of the present study.

Lee et al.[30] reported that resin-based sealers have higher bond strength than other sealers. The higher bond strength of resin-based sealers might be due to the formation of covalent bonds between their open epoxide ring and any exposed amino groups in collagen [31]. According to the findings of the present study, when using this type of sealer, it is important that final irrigation should not be performed with NaOCl.

In the present study, inspection of the specimens revealed that the predominant fracture type was mainly adhesive (sealer-dentine interface) for all groups (Table 2). This finding clearly suggests an inadequate level of adhesion between the sealer and the dentin in terms of bond strength.

Pimentel Correa et al.[18] evaluated the efficacy of different concentrations and different application times of sodium thiosulfate for restoring adhesion to pulp chamber dentin treated with NaOCl and EDTA, and found that the use of 5% sodium thiosulfate for 10 minutes gave the best results for increasing the bond strength of composite resin. Thus, in the present study, 5% sodium thiosulfate for 10 minutes was used for neutralization of NaOCl.

In a recent study evaluating the efficacy of sodium thiosulfate for restoring adhesion to pulp chamber dentin, it was found that the neutralization effect of sodium thiosulfate on NaOCl was dependent on both the physical action and the chemical action.[18] Similarly, in the present study, distilled water was tested in one group to determine whether the effect of sodium thiosulfate is only chemical or physical. In the present study, although there were no significant differences between the distilled water and control groups, the bond strength values in the sodium thiosulfate group were higher than those of the control group, with a statistically significant difference. This result confirmed the results of the previous study demonstrating that sodium thiosulfate affects NaOCl by means of physical and chemical actions.[18] The physical action of sodium thiosulfate is that it washes out NaOCl. Furthermore, the chemical action depended on the neutralization effect of sodium thiosulfate—an antioxidant—on residual free-radicals formed on root dentin after irrigation with NaOCl, which was one of the oxidizing substances.[18, 24, 25] In other words, it might be related to changes in the redox potential of the root dentin.[29]

In the present study, the push-out bond strength test was performed on the specimens with standardized holes and the same thickness, increasing the internal validity of the study.[32] Additionally, other variables, such as irrigation with NaOCl, citric acid were applied to whole specimens. Moreover, the holes were fully filled only with sealer, resulting in the application of load directly to the sealer, thus eliminating erroneous interpretation of the results.[32, 33] However, the dentin source was different among the groups, resulting in bias because of different variables, such as relative mineralization and hardness.[34] This is a limitation of the present study.

In a recent initial assessment of sodium thiosulfate on cell viability, 5% sodium thiosulfate was found to be compatible with cell viability.[18] Thus, it can be claimed that sodium thiosulfate can be used in

routine clinical use. Within the limitations of the present study, it can be concluded that 5% sodium thiosulfate for 10 min increases the bond strength of the sealer to NaOCl- and citric acid-treated dentin.

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