

EFFECTS OF IRRIGANT ACTIVATION AND SURFACTANT ADDITION ON TISSUE-DISSOLVING CAPACITY OF SODIUM HYPOCHLORITE

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ABSTRACT

Background and Aim: The study aimed to evaluate the effects of activation and surfactant addition on the tissue-dissolving capacity of sodium hypochlorite.

Materials and Methods: Segments of bovine muscle tissue were prepared and weighed thrice using a precision balance (n=70). Each tissue sample was placed in 10 mL of one of the following solutions for 5 minutes at 37°C: 5% sodium hypochlorite, 5% sodium hypochlorite with surfactant (0.008% benzalkonium chloride), or distilled water (control). In the activation subgroups, the solutions were activated using ultrasonic energy or XP Endo Finisher file for 15 seconds per minute. No activation was performed in the control group. Finally, the tissue samples were slightly dried and weighed thrice. The percentage of weight loss for each sample was calculated. Data were analyzed using the 2-way analysis of variance and Tukey test.

Results: No change was observed in the weight of tissue samples in the control group. Benzalkonium chloride addition did not affect the tissue-dissolving capacity of sodium hypochlorite ($p>0.05$). Both activation methods significantly increased the tissue-dissolving efficiency of sodium hypochlorite solutions ($p<0.05$). Activation with the XP Endo Finisher file was associated with more weight reduction compared to ultrasonic activation ($p<0.05$).

Conclusion: Irrigant activation using the XP Endo Finisher file can be recommended to improve the tissue-dissolving capacity of sodium hypochlorite.

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Keywords: Benzalkonium Chloride, Sodium Hypochlorite, Tissue Dissolution, XP Endo Finisher File

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İRRİGANT AKTİVASYONUNUN VE YÜZEY AKTİF MADDE İLAVESİNİN SODYUM HİPOKLORİTİN DOKU ÇÖZÜCÜLÜĞÜ KAPASİTESİ ÜZERİNE ETKİLERİ

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Sorumlu Yazar

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ÖZ

Amaç: Bu çalışmanın amacı aktivasyon ve yüzey aktif madde ilavesinin sodyum hipoklorit doku çözücülüğü kapasitesi üzerindeki etkilerini değerlendirmektir.

Gereç ve Yöntem: Sığır kas dokusu segmentleri hazırlandı ve hassas tartı kullanılarak üç kez tartıldı (n=70). Her doku örneği 37°C'de belirtilen 10 mL'lik solüsyonlara 5 dakika süreyle yerleştirildi: %5 sodyum hipoklorit, yüzey aktif madde içeren %5 sodyum hipoklorit (%0.008 benzalkonyum klorür) veya distile su (kontrol). Aktivasyon alt gruplarında solüsyonlar, ultrasonik enerji veya XP Endo Finisher eğesi kullanılarak her 1 dakikada 15 saniye süreyle aktive edildi. Kontrol grubunda aktivasyon yapılmadı. Son olarak, doku örnekleri hafifçe kurutuldu ve üç kez tartıldı. Her örnek için ağırlık kaybı yüzdesi hesaplandı. Veriler 2-yönlü varyans analizi ve Tukey testi kullanılarak analiz edildi.

Bulgular: Kontrol grubunda doku örneklerinin ağırlığında bir değişiklik olmadı. Benzalkonyum klorür ilavesi, sodyum hipoklorit doku çözme kapasitesini etkilemedi ($p>0.05$). Her iki aktivasyon yöntemi de sodyum hipoklorit solüsyonlarının doku çözme etkinliğini önemli ölçüde arttırdı ($p<0.05$). XP Endo Finisher eğesi ile aktivasyon, ultrasonik aktivasyona göre daha fazla ağırlık kaybı ile ilişkilendirildi ($p<0.05$).

Sonuç: Sodyum hipoklorit doku çözücülüğü yeteneğini geliştirmek için XP Endo Finisher eğesi kullanılarak irrigant aktivasyonu önerilebilir.

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Anahtar Kelimeler: Benzalkonyum Klorür, Doku Çözücülüğü, Sodyum Hipoklorit, Xp Endo Finisher Eğe

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INTRODUCTION

It is essential to thoroughly irrigate and disinfect the root canal system for the success of endodontic therapy.¹ Because of the nature of the root canal anatomy, complex morphologic structures such as apical ramifications, accessory, and lateral canals cannot be mechanically prepared.² Therefore, microorganisms and necrotic tissues must be eliminated from these inaccessible areas through an adequate irrigation procedure.²

Sodium hypochlorite (NaOCl) is the most commonly used root canal irrigant due to its high antimicrobial effect, biofilm removal capacity, and tissue-dissolving features.³ In order to enhance the effectiveness of NaOCl, various methods such as increasing the temperature and concentration of the solution have been proposed.⁴ Although increasing the temperature of the NaOCl solution provides positive results, the temperature of the solution decreases as soon as heated NaOCl is applied to the root canal; thus, NaOCl loses its effectiveness.^{5,6} The use of high concentration of NaOCl is not recommended because of its increased toxicity and irritation potential.⁵

Surfactant addition to NaOCl can increase the tissue solubility and improve the penetration of the solution into dentinal tubules by decreasing the surface tension.^{7,8} Benzalkonium chloride (BAC) is a surfactant agent with antimicrobial properties.⁹ A recent study suggested to add 0.008% BAC to NaOCl since the contact angle and surface energy of the solution were reduced significantly without negatively affecting the free chloride content and cytotoxicity at this concentration.¹⁰

Another way to increase the effectiveness of irrigation is through the activation of the solution.⁵ Ultrasonically activated irrigation (UAI) relies on the transmission of energy from an oscillating file or smooth wire that operates at 25–30 kHz to an irrigant in the root canal.¹¹ The energy is transmitted through ultrasonic waves and induce acoustic streaming and cavitation of irrigant.¹¹ Several studies revealed that UAI was highly effective in cleaning root canals^{12–14} while other studies reported that UAI was not superior to syringe irrigation.^{15,16} XP Endo Finisher file (FKG, La Chaux-de-Fonds, Switzerland) has been recently introduced as an irrigant activation system.¹⁷ The instrument has a small core size of #25 and no taper. The alloy properties enable the file to adapt the root canal anatomy by the transformation from the martensitic phase to the austenite phase when exposed to body temperature.¹⁷ This allows the

file to expand to 6 mm in diameter and to clean areas that cannot be accessed by routine instrumentation.¹⁷ Previous studies reported that the XP Endo Finisher file was highly effective in smear layer removal,¹⁸ hard tissue removal,¹⁹ and medicament removal from root canals.²⁰ However, the number of studies in the literature on its effects on tissue dissolution is limited. The use of the XP Endo Finisher file and surfactant addition to NaOCl may increase the tissue-dissolving activity. Therefore, the purpose of the present study was to analyze the effects of surfactant addition and irrigant activation on the tissue-dissolving feature of NaOCl. Therefore, the hypothesis of “the surfactant addition to NaOCl or irrigant activation has no significant effect on tissue-dissolving capacity” was tested as the null hypothesis.

MATERIALS AND METHODS

Bovine muscle tissue was used for the experiments. Equal sized segments of tissue samples were prepared. The samples were weighed thrice using a precision balance (Radwag Balances and Scales, Radom, Poland) with the precision of 10^{-5} g, and the mean values were recorded before the experiments (Figure 1a). The pre-weighed samples were 65 ± 5 mg.

5% NaOCl solutions (Werax, Izmir, Turkey) with and without 0.008% BAC (Zefiran, Dermosept, Aktas Saglik Kozmetik ve Temizlik Urn. San. Tic. Ltd. Sti, Istanbul, Turkey) were tested. To prepare the solutions with a surfactant, 0.08 ml of BAC with a concentration of 10% was added to 100 ml of 5% NaOCl. On the other hand, distilled water was used as an irrigant in the control group. The tissue samples were randomly divided into 7 groups as follows ($n=10$):

1. 5% NaOCl-no activation
2. 5% NaOCl+BAC- no activation
3. 5% NaOCl- ultrasonic activation
4. 5% NaOCl+BAC- ultrasonic activation
5. 5% NaOCl- XP Endo Finisher activation
6. 5% NaOCl+BAC- XP Endo Finisher activation
7. Distilled water-no activation (control group)

Samples in each group were added to glass vials containing 10 ml of the corresponding solution for 5 min. The vials were placed in a water bath containing distilled water at 37°C (Figure 1b). In the ultrasonic activation groups, an ultrasonic K-file (size 25, 0.02 taper) (Satelec-Acteon, Merignac, France) coupled to the file-holding adapter of an ultrasonic system handpiece (Satelec P5 Newtron XS, Acteon Group, Merignac, France) was operated at medium

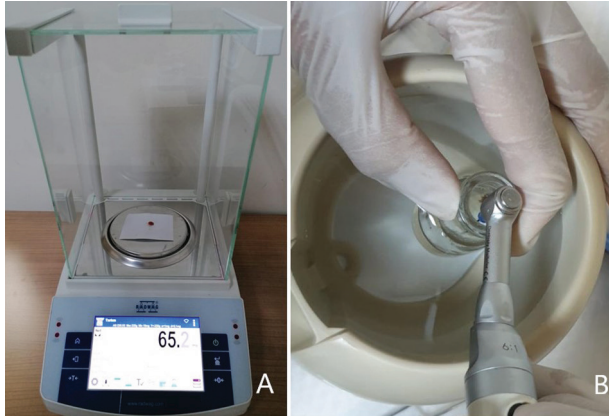


Figure 1. The experimental set-up. a) weight measurement using an precision balance b) irrigant activation in a vial placed in a water bath containing distilled water at 37°C.

power. In the XP Endo Finisher activation groups, the XP Endo Finisher file (size 25, non-tapered) (FKG, La Chaux-de-Fonds, Switzerland) was used with X-Smart Motor (Dentsply Sirona, Ballaigues, Switzerland) with the speed of 800 rpm and torque of 1 N.cm. Tips used in the activation groups were submerged up to 10 mm in solution and operated at a distance of approximately 5 mm from the tissue. In the activation groups, agitation of the solutions was performed for a 15-s period per minute for 5 minutes. At the end of 5 minutes, tissue samples were removed from the vials, dried slightly, and weighed thrice. The mean values were recorded. The percentage of weight loss for each sample was calculated.

The statistical analysis was performed using the Statistical Package for the Social Sciences software (SPSS 20.0, SPSS Inc, Chicago, IL). Data were analyzed using the 2-way

analysis of variance and Tukey test. A p-value of less than 0.05 ($p < 0.05$) was considered statistically significant.

RESULTS

The results are presented in Table 1. The experimental groups presented loss in tissue weight whereas no tissue dissolution was observed in the control group. The addition of BAC did not have a significant effect on the tissue-dissolving capacity of NaOCl ($p=0.199$). The interaction between surfactant addition to NaOCl and activation of NaOCl was not found significant ($p=0.998$). The tissue-dissolving capacity was found to significantly increase when the test solutions were activated ($p < 0.001$). Activation with the XP Endo Finisher file was associated with more weight reduction compared to ultrasonic activation ($p=0.007$).

DISCUSSION

The main reason for post-treatment apical periodontitis is the bacterial persistence in the root canal system due to insufficient cleaning and disinfection.²¹ In this regard, irrigation with NaOCl has a crucial role in endodontic treatment to eliminate organic compounds such as microorganisms and necrotic tissue.² Therefore, one of the most researched topics in endodontics is the strategies to increase the effectiveness of NaOCl. According to the present findings, adding a surfactant to NaOCl had no effect on the tissue-dissolving capacity while both activation methods resulted in significant weight reduction. Therefore, the null hypothesis was partially rejected.

In the present study, bovine muscle tissue was used to evaluate the tissue-dissolving capacities of the groups. In

Table 1. The mean and standard deviation values of weight changes (%) of the groups

Groups	Percentage of weight reduction (Mean±SD)
5% NaOCl- no activation	9.17±3.02 ^a
5% NaOCl+BAC- no activation	10.90±5.78 ^a
5% NaOCl- Ultrasonic activation	16.71±2.55 ^b
5% NaOCl+BAC- Ultrasonic activation	18.28±4.75 ^b
5% NaOCl- XP Endo Finisher activation	21.59±5.90 ^c
5% NaOCl+BAC- XP Endo Finisher activation	23.30±5.97 ^c
Distilled water- no activation(control group)	No reduction

* Two-way analysis of variance and Tukey test were used for the statistical analysis. Different superscript letters indicate significant differences among groups ($p < 0.05$). SD: Standard deviation

previous studies, various types of tissue samples such as porcine muscle tissue,²² porcine palatal mucosae,²³ bovine muscle tissue,⁴ and bovine pulp²⁴ were used. Bovine tissue samples have several advantages over human dental pulp such as their availability²⁵ and better standardization of the surface area of the samples.²³

It was reported that surfactant addition to NaOCl did not directly change its tissue-dissolving capacity²⁶ but it could decrease the contact angle and surface tension, thus increasing the penetration of the solution into the tissues and eventually increasing the organic tissue solubility.²⁷ However, in the present study, the addition of 0.008% BAC did not result in a significant increase in tissue dissolution which is in line with previous studies.^{26,28,29} The contradictory results on this subject may be due to the different experimental designs of studies such as the temperature, concentration, and pH of the solution used, the type and concentration of surfactant added, and the application time of the solution. According to a previous study, tissue-dissolving capacity was directly dependent on the concentration of solutions and application time.³⁰ In the present study, 0.008% BAC was added to NaOCl since this concentration was recommended as an effective dose to reduce surface tension without showing harmful effects.¹⁰ Although another study comparing the surface tension of NaOCl with the addition of various concentrations of BAC reported that 5.25% NaOCl should be modified with 0.1% BAC,³¹ and higher BAC concentrations may lead to increased cytotoxicity.³²

In the present study, similar to previous studies, irrigant activation groups caused significantly more tissue weight loss than non-activated groups.^{4,33} According to a previous review, the ultrasonic activation of NaOCl still remains the gold standard in root canal cleaning³⁴. Therefore, we decided to compare the effect of the XP Endo Finisher file, which was a relatively new system, on tissue dissolution with UAI. The increase in the tissue-dissolving capacity of NaOCl with ultrasonic activation may be related to the increase in temperature of the solution.³⁵ Another reason may be acoustic streaming and cavitation which occurs in the irrigant due to ultrasonic waves.¹¹ In the present study, XP Endo Finisher file activation significantly dissolved more tissue than UAI. In line with the present findings, XP Endo Finisher file activation was found to be more effective than ultrasonic activation on tissue removal from simulated internal resorption cavities.³⁶ Furthermore, XP Endo Finisher

file activation provided better irrigant diffusion through the root canal system than ultrasonic activation in another study.³⁷ In the present study, relatively less activity of UAI on tissue dissolution may be explained by the experimental design since the activation was carried out in glass vials instead of the narrow and closed root canal system. In the current test design, the direct effect of ultrasonic waves may have decreased until reaching the tissue. It was reported that the cavitation effect is limited to only a few micrometers from the file surface.³⁸ On the other hand, the current model was particularly chosen to analyze the direct effect of the XP Endo Finisher file on tissue dissolution. The shape memory effect of the XP Endo Finisher file depends on the transformation of its martensitic phase to the austenitic phase when exposed to intracanal temperature.¹⁷ Therefore, the temperature of the solutions was kept at 37°C to simulate intracanal temperature throughout the experiments. As the XP Endo Finisher file expands to 6 mm in diameter and its shape changes in the root canal at 37°C, it can also remove tissue mechanically.³⁶ The purpose was to eliminate this mechanical effect and purely evaluate its effects on tissue-dissolving capacity in the present study. It is noteworthy to mention that the current test model does not reflect the complex anatomy of the root canal system. However, it provides standardized settings and focuses on tissue dissolving by eliminating mechanical removal of tissue.³⁹

CONCLUSIONS

Within the limitations of the present study, the addition of 0.008% BAC to NaOCl did not increase the tissue-dissolving capacity. Also, the activation with the XP Endo Finisher file was found to be more effective compared to the UAI technique in improving the tissue-dissolving capacity of NaOCl.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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