Original Article / Özgün Araştırma

Meandros Med Dent J
doi:10.4274/meandros.galenos.2022.60565
Meandros Med Dent J 2023;24(4):268-273

Influence of Sonic Activation Duration on Root Canal Temperature Increase

Sonik Aktivasyon Süresinin Kanal İçi Isı Artışına Etkisi

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Abstract

Objective: This study investigated intracanal heat changes when the EDDY sonic activation system was used for different durations.

Materials and Methods: Sixty (15 per group) maxillary canine teeth were used in this study. Teeth were decoronate and enlarged up to the T-endo must M40 file. Three thermocouples were inserted on the tooth: one at the apical foramen (T1), one at the working length (WL) of -5 mm (T2), and one at the WL of -10 mm (T3). A fixed setup was established, and an irrigation solution inside the root canal was activated for 10 (S10), 20 (S20), 30 (S30), and 60 (S60) seconds per group with an EDDY tip.

Results: The S10 group exhibited less temperature change and the S60 group demonstrated a statistically significant temperature increase.

Conclusion: Prolonged activation durations resulted in a greater temperature increase due to root canal dry out. This temperature is more likely to transmit periodontal tissues than the increasing effect of sodium hypoclorite because of the scattered solution. Shorter activation durations with more sicluses would be more beneficial.

Keywords: Irrigation, EDDY, intracanal temperature

Öz

Amaç: Bu çalışmada sonik irrigasyon aktivasyon sistemi olan EDDY'nin farklı sürelerde kullanıldığında oluşan kanal içi ısı değişimleri incelenmiştir.

Gereç ve Yöntemler: Bu çalışma için 60 adet üst kanin diş (n=15) kullanılmıştır. Dişler dekorone edilip kanallar T-endo must M40 numaralı eğeye kadar genişletilmiştir. Dişlerin üzerine biri apical foramen (T1), biri çalışma boyundan 5 mm kısa (T2) ve diğeri çalışma boyundan 10 mm kısa (T3) olacak şekilde 3 adet termokupl bağlanmış ve sabit bir düzenek oluşturularak kök kanalları içerisindeki irrigasyon solüsyonu gruplara göre 10 (S10), 20 (S20), 30 (S30), ve 60 (S60), saniye süreyle aktive edilmiştir.

Bulgular: S10 grubunda daha az ısı değişimi saptanmış olup S60 grubunda anlamlı düzeyde fazla ısı artışı görülmüştür.

Sonuç: Aktivasyon süresinin uzaması kanal içinde bulunan solüsyonun saçılarak kanalın kurumasına sebep olarak daha yüksek ısı artışına neden olmuştur. Açığa çıkan bu ısının solüsyonun saçılmasından dolayı sodyum hipokloritin etkinliğini artırmaktan ziyade periapikal dokulara iletilmesi muhtemeldir. Kısa aktivasyon sürelerinin daha fazla aktivasyon döngüsü ile birlikte uygulanması daha yararlı olacaktır.

Anahtar Kelimeler: İrigasyon, EDDY, kanal içi ısı

Introduction

Successful endodontic therapy involves removing bacteria and organic remnants from the root canal space (1). Chemomechanic preparation is crucial for this aim. It includes removing debris, bacteria, microorganisms, and endotoxins inside the root canal by root canal preparation and irrigation (2). But even when the performance of chemomechanic preparation follows all protocols, some bacteria can still

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Received/Geliş Tarihi: 07.04.2022
Accepted/Kabul Tarihi: 06.10.2022

survive (2). Sodium hypochlorite (NaOCl) is the most common irrigation solution because of its high antimicrobial effectiveness (3). The effectiveness of NaOCl is related to temperature, activation as much as contact time, renewal rate, and concentration (3). NaOCl is usually applied with a conventional syringe (4). However, conventional syringes are ineffective in reaching all root canal irregularities (5) and apical thirds due to the vapor lock effect (6). Several studies have shown that the effectiveness of NaOCl can be increased via activation methods (7-9). Therefore, irrigant activation systems have gained popularity.

EDDY (VDW, Munich, Germany) is a recently introduced sonic irrigation activation device that is used with a conventional air scaler with a flexible polyamide irrigation tip (10). Its oscillation power is much higher than that of other equivalent sonic devices (11). Unlike ultrasonic devices, EDDY has a special polymer rod that does not cause dentinal deformations during oscillation (12). It has also demonstrated promising results in terms of canal cleanliness (9,10,12). Different activation durations were performed in several studies (13-15), some of which used 10 seconds for activation (15) while others used 20 (16) seconds or 30 seconds (17). None, however, evaluated temperature changes with different activation durations. The goal of the present study was to determinate the most suitable activation time to protect thermal damage of the periodontal tissue.

Materials and Methods

Sample Size Calculation

Power calculation was performed based on a previous study (18) with the aid of a G-power 3.1.9.4 program. The minimum sample size was determined as 12 for the whole study. However, in order to increase the reliability of the study and in consideration of the number of samples in the reference article, 15 samples per group were chosen.

Sample Preparation

Ethical committee approval was acquired from the Sakarya University Faculty of Medicine Ethical Research Board (approval number: 567, date: 09.12.2021). Forty-five single-rooted maxillary canine teeth (15 per group) with a single root canal and less than a 5° root canal curvature were used based on Schneider (19). Buccal and proximal radiographs were taken to confirm that the teeth had a single root canal. Extracted teeth were examined with an operating microscope (Zumax OMS2350, Zumax Medical Co. Ltd, Jiangsu, China) under x20 magnification to confirm the absence of root cracks and fractures. Teeth with cracks and fractures were replaced with new teeth. Root surfaces were cleaned with curette and ultrasonic scalers to remove calculus and soft tissue remnants and were stored in 0.5% thymol solution until use.

Teeth were decoronated to standardize the working length (WL) at 21 mm (±1 mm) with a slow-speed diamond saw (IsoMet, Buehler, Lake Bluff, IL, USA). To mimic a pulp chamber, the coronal 3 mm of the canal was enlarged using a round bur (no. 23, Dentsply Maillefer) with a diameter of 2.3 mm. Apical patency was controlled with K-files ISO 10. Only teeth with a canal width of approximately ISO 15 near the apical foramen were included. The canals were instrumented with T-endo must reciprocating files (Dentac, İstanbul, Turkey) up to M40 using an Ai endodontic motor (Woodpecker, Guilin, China) in "T-endo must" mode. During root canal enlargement, root canals were irrigated using 2 mL of 3% sodium hypochlorite (NaOCl, Coltene/Whaledent, Altstätten, Switzerland) for 20 seconds with a 30-gauge endodontic needle (NaviTip, Ultradent, UT, USA). Following root canal enlargement, the coronal 3 mm of the samples were enlarged with a round bur (no. 23, Dentsply Maillefer).

After root canal instrumentation, three holes were created to adapt K-type thermocouples connected to a datalogger to measure intracanal temperature from the apical middle and coronal thirds during irrigation activation. Two of the holes were drilled on the buccal side of each root with a diameter of 0.5 mm at a distance of 5 and 10 mm from the apical foramen, and one was drilled at the apical foramen using rose burs (diameter = 0.5 mm; Komet, Lemgo, Germany).

The roots were positioned in modified plastic molds. Three holes were also prepared on the plastic molds and Type K thermocouples were passed through the holes on the plastic mold and inserted at the holes which are on the teeth and positioned just before entering the main root canal (Figure 1). Thermocouple which locates at the apical foramen called T1, middle tip named as T2 and coronally located thermocouple named as T3 (Figure 1). Then, the thermocouples were fixed in their position by a resin composite. The position of the thermocouples was controlled by radiographs. The molds were filled with alginate (Henry Schein, Melville, NY) to stabilize the thermocouples.

To measure the temperatures, the thermocouples were connected to a multi-channel datalogger (Pico Data Logger, TC-08, St Neots, UK), which transmits temperature levels to a computer. To simulate body temperature, the samples were stored at a temperature of 37 °C for 24 hours. All procedures were performed in an incubator.

The next day when thermocouples measured 37±1 °C activation procedure started, a room temperatured 3% NaOCl was delivered inside the root canal, and activation was performed by a sonic activation system (EDDY, VDW, Munich, Germany). Groups are as follows; S10: 10 seconds, S20: 20 seconds, S30: 30 seconds, S60: 60 seconds sonic activation. The sonic tip was placed 3 mm from the thermocouple, which was located at the apex. During irrigation activation process 4 mm vertical strokes were applied with the EDDY tip. Temperature changes were recorded during whole procedure with 5 seconds intervals. Minimum and maximum temperatures were recorded after irrigation and activation for each group and the data analyzed statistically.

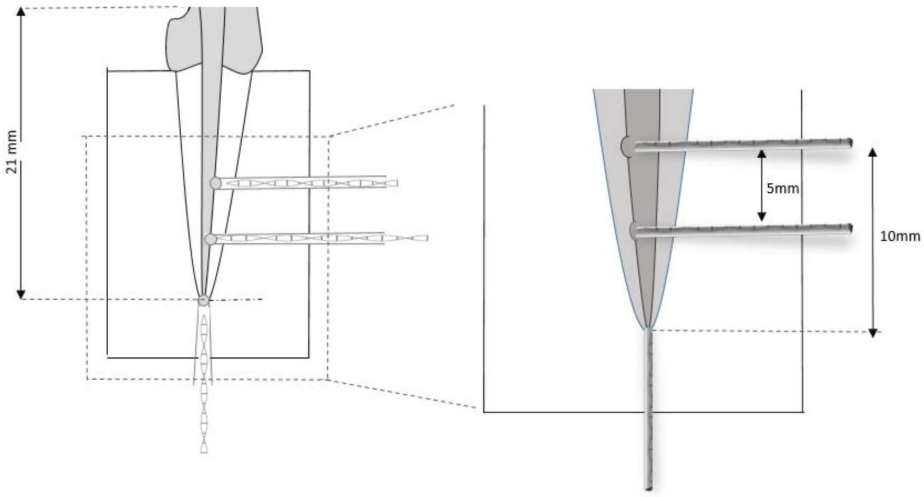

Figure 1. Shematic image of thermocouple positions

Statistical Analysis

Statistical analysis were performed using One-Way ANOVA and a Bonferroni post-hoc test on the IBM SPSS Statistics Version 25 program. Normal distribution control was performed using a Shapiro-Wilk test and Kurtosis-Skewness values ($p>0.05$).

Results

Mean temperature change between onset -irrigation and irrigation- activation can be seen in Table 1. Both changes for all groups were statistically significant. İrrigation significantly reduced, and activation significantly increased the temperature ($p<0.05$).

A One-Way ANOVA test was used to evaluate the difference between activation duration and thermocouple location. Temperature changes between irrigation and activation were found to be statistically significant ($p<0.05$). Post hoc tests were used to determine which periods were statistically significant.

For all activation duration periods, statistically significant difference were seen between T1 and T2 ($p<0.05$). The temperature reduction with irrigation and temperature increase with activation was higher at T2 level. For all activation duration periods, a statistically significant difference was observed between T1 and T3 levels ($p<0.05$). The temperature was reduced more with the irrigation and was increased with the activation at level of T3. The difference between T2 and T3 was statistically insignificant ($p>0.05$).

With the activation; S60 group revealed a statistically significant difference from the S10 group at the T1 level. At the T2 level, there were statistically significant differences between the S10 group and the other groups. The S20 group also differed from the S60 group ($p<0.05$).

A Tamhane test was used to determine the difference between the duration periods. The difference between the T1 and T2 was found to be statistically significant for irrigation and activation ($p<0.05$). The temperature decreased with the irrigation and increased with activation increases at that level. The difference between the T1 and T3 was also found significant for all activation periods ($p<0.05$). The temperature decreased more at the T3 level with irrigation and increased more with activation. There was no statistically significant difference between the T2 and T3 levels ($p>0.05$).

Activation significantly increased the temperature for all groups, and they all differed from the S10 group ($p<0.05$). The S20 group also differed from the S60 group ($p<0.05$).

At the level of T3 mean temperature was found as 49,42±4,54 °C for S60 group. Statistically significant difference was seen at this level between the S60 group and all the others ($p<0.05$), S10 and all the others were significant ($p<0.05$), difference between S20 and S30 groups was found insignificant ($p>0.05$).

Longer activation periods caused higher intracanal temperatures.

Discussion

This study was designed to investigate intracanal temperature increase with different activation durations when a sonic activation system (EDDY) was used. There are some previous studies that evaluated temperature increase caused by different activation devices (18,20,21). But none of them compared the thermal effect of different durations of sonic activation. Although increasing the temperature of the solution is recommended to increase its effectiveness (22), it is known that temperature values higher than 47 °C can cause damage to periodontal tissues (23). For this reason, the most accurate protocol that would respect biological tissue was sought as no prior study has done so.

Table 1. Mean temperature levels for groups

Activation			Onset			Irrigation		
T1	T2	T3	T1	T2	T3	T1	T2	T3
S10	36.59±0.60^{a,A}	36.52±0.76^{a,A}	37.14±0.67^{a,A}	35.23±0.81^{a,A}	29.24±0.51^{a,B}	29.73±0.84^{a,B}	36.46±0.88^{a,A}	38.62±1.76^{a,C}	40.18±2.01^{a,C}
S20	37.73±0.79^{a,A}	37.53±1.15^{a,A}	37.87±1.58^{a,A}	36.32±0.86^{a,A}	29.60±0.64^{a}	30.31±0.45^{a,B}	37.38±0.29^{a,A}	41.39±2.19^{b,C}	43.63±2.46^{b,C}
S30	37.13±0.50^{a,A}	36.92±1.16^{a,A}	37.35±0.98^{a,A}	36.05±0.36^{a,A}	29.79±0.75^{a,B}	30.05±0.65^{a,B}	37.43±0.65^{a,A}	43.57±2.42^{b,C}	45.20±2.35^{b,C}
S60	36.95±0.43^{a,A}	37.39±0.56^{a,A}	37.46±0.60^{a,A}	35.40±0.54^{a,A}	29.78±0.89^{a,B}	29.92±0.65^{a,B}	37.81±1.00^{b,A}	47.08±5.05^{c,C}	49.42±4.54^{c,C}

Uppercase letter indicate differences between columns, lowercase letters indicate differences between rows

In the present study, single-rooted maxillary canine teeth were used because they have strong roots and thus helped to establish the study set up (18,24). Samples were decoronated to standardize WL and the amount of solution inside the root canal, and the coronal 3 mm of the canals were enlarged with a 2.3 mm round bur to create a pulp chamber for a solution reservoir (8).

Some of the previous studies placed thermocouples only buccal side of the root (18,20). But in the present study one of the thermocouples was placed at the apical foramen to see temperature change at that point, because of high temperature at the apical foramen might cause post-operative discomfort.

In the current study, samples were fixed with alginate and stored in an incubator for 24 hours before initiation of intracanal heating procedures to imitate intraoral conditions at 37 ˚C and 100% humidity. The study set up was suggested by Donnermeyer et al. (18) for better reflection of intraoral conditions.

In the previous studies, different durations of sonic activation with EDDY was used to compare its effect with other systems (10,25). In the present study 10, 20, 30, and 60 seconds were used as an activation duration, all of which could be used for irrigation activation, were employed to evaluate temperature change.

In a previous study, which studies temperature changes between ultrasonic activation, thermal activation and preheated NaOCl, recordings were done at 10, 20, 40 and 60 seconds (20) in this study recordings were done in every 5 seconds to get more accurate results.

Temperature decrease with irrigation and temperature increase with activation were observed for all study groups. Temperature changes at the T1 point were lowest. This finding is compatible with the other studies (21,24). It could be explained by closed-end study design prevents irrigation solution move towards apically due to vapor lock effect and temperature decrease were lower with the irrigation at this point. Temperature changes between the T1 and T2 and the T1 and T3 were found to be statistically significant for all groups. This can be explained by the fact that the solution was evicted towards the pulp chamber instead of transferring apically during irrigation and activation. This finding is compatible with Donnermeyer et al. (24).

Donnermeyer et al. (24) studied temperature increasing effect of sonic activation with EDDY when used 30s and compared with PIPS, ultrasonic activation, preheated sodium hypoclorite and another sonic activation device. In their study highest temperature measured was around 40 ˚C which is slightly less than our present study. This difference may be due to the fact that their samples contain more NaOCl, which could compansate temperature rise, due to the longer WL.

The S10 group exhibited less temperature increase than the other groups for all levels. S20 group demonstrated significantly less temperature change than the S60 group.

S60 group yielded a significantly higher temperature with activation. This could be due to solution scattering during activation, which leads to root canal dry out and causes temperature increase. Activation increased the temperature more at the level of T3 and less thermal change was seen at the T1 level for all groups. Although there is no study to compare this finding with sonic activation Zeltner et al. (21) showed similar results in their study with ultrasonic activation. Greater temperature increase at the level of T3 may be associated with the solution moving coronally due to a closed-end study design, and cavitation may be more effective at that level because root canal diameter is larger than T1 and T2.

Conclusion

In the current study, it was observed that during irrigation activation most of the solution in the root canals was scattered in the first seconds of activation and moved away from the root canal. In relation to this, findings of the present study showed that prolonged activation time increased temperature beyond biological limits. Therefore the heat caused by irrigation activation is more likely to transmit periodontal tissues than increasing effectiveness of the solution. As a result instead of one long activation period, multiple activation sessions with short durations would be beneficial to control unnecessary temperature increase inside the root canal system. Further studies are needed to understand to what extent temperature increases are transmitted to alveolar bone and if shorter activation periods such as 10 or 20 seconds would be preferred, how many sicluses could provide sufficient antimicrobial and debris removal effect.

Ethics

Ethics Committee Approval: Ethical committee approval was acquired from the Sakarya University Faculty of Medicine Ethical Research Board (approval number: 567, date: 09.12.2021).

Informed Consent: Informed consent is not required.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: A.K.E., Design: A.K.E., F.F., Data Collection or Processing: F.F., Analysis or Interpretation: F.F., Literature Search: A.K.E., Writing: A.K.E.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

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