

# The Efficacy of QMix on the Root Canal Dentin After Different Exposure Time Periods: A SEM and an EDS Analysis

Qmix'in Farklı Uygulama Süreleri Sonrası Kök Kanal Dentini Üzerine Etkisi: SEM ve EDS Analizi

## ABSTRACT

**Aim:** The irrigation solutions and chelating agents are able to change the chemical composition of dentin. This study aimed to evaluate the efficacy of QMix on the removal of smear layer and the Ca/P ratio of root canal dentine after different exposure time periods.

**Material and Method:** Sixty extracted teeth were prepared and divided into 5 groups according to the application time of the solution (n=12). In group 1, no irrigation was performed (control). The other groups were defined as follows consecutively; QMix solution were used for 1, 3, 5 and 10 minutes. Smear layer scores, erosion scores and Ca/P ratios of each group were evaluated by SEM and EDS.

**Results:** In apical and middle regions, smear layer scores of 10 minute group, was significantly lower than 1 minute group (P<0.05). No peritubular or intertubular erosion was observed according to the erosion scores. Control group showed higher Ca/P ratio than the other groups without significant differences (P>0.05).

**Conclusion:** QMix is able to remove smear layer effectively in 10 minutes without causing any erosion in dentinal tubules or alteration in the Ca/P ratio.

**Key words:** QMix, Scanning electron microscope, Irrigation

## ÖZ

**Amaç:** İrrigasyon solüsyonları ve şelasyon ajanları dentinin kimyasal kompozisyonunu değiştirebilmektedir. Bu çalışmanın amacı, farklı uygulama süreleri sonrası QMix'in smear tabakasını uzaklaştırma etkinliği ve kök kanal dentininde Ca/P oranına etkisini değerlendirmektir.

**Gereç ve Yöntem:** Atmış adet çekilmiş diş şekillendirildi ve solüsyonun uygulanma sürelerine göre 5 gruba ayrıldı (n=12). Grup 1'de irrigasyon uygulanmadı (kontrol). Diğer gruplar sırasıyla şu şekilde tanımlandı; QMix solüsyonu 1, 3, 5 ve 10 dakika süre ile uygulandı. Smear tabakası skorları, erozyon skorları ve Ca/P oranı SEM ve EDS ile değerlendirildi.

**Bulgular:** Apikal ve orta bölgede smear tabakası skorları 10 dakika grubunda 1 dakika grubuna göre anlamlı derecede düşük çıktı (P<0.05). Erozyon skorlarına açısından herhangi bir peritübüler veya intertübüler erozyon görülmedi. Kontrol grubunda diğer gruplara göre daha yüksek Ca/P oranı ortaya çıktı ancak anlamlı fark görülmedi (P>0.05).

**Sonuç:** QMix dentin tübüllerinde herhangi bir erozyona yol açmadan ve Ca/P oranında değişikliğe neden olmadan 10 dakika içerisinde smear tabakayı uzaklaştırabilmektedir.

**Anahtar sözcükler:** QMix, Tarama elektron mikroskobu, İrrigasyon

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## INTRODUCTION

Bacteria and their by-products are the major causes of the pulpal and periapical diseases (Kakehashi *et al.* 1965). Thus, the main goals of root canal treatment are the removal of bacteria and prevention of recontamination of the root canal system. The chemomechanical removal of bacteria and infected dentine from the root canals include root canal preparation process. The smear layer which occurs during root canal preparation contains organic debris, inorganic debris, bacteria and their by-products. The smear layer covers the instrumented walls and may prevent the penetration of intracanal medicaments into the dentinal tubules and interferes with the close adaptation of root filling materials to canal walls. Recent studies indicated that the removal of the smear layer is essential for more thorough disinfection of the root canal system and for a better adaptation of materials to the canal walls (2).

Irrigation with a combination of ethylenediaminetetraacetic acid (EDTA) and sodium hypochlorite (NaOCl) is the most commonly used method for removing smear layer from root canals. This combination is able to remove the smear layer effectively in the coronal and middle thirds rather than the apical part (3,4). Additionally, citric acid, maleic acid, EDTAC and MTAD were used as an agent for removing smear layer (5,6).

QMix (Dentsply Tulsa Dental, Tulsa, OK) is a new solution containing a bisbiguanide antimicrobial agent, a polyaminocarboxylic acid calcium-chelating agent and a surfactant, with antimicrobial agents for the smear layer removal, proving to be as effective as 17% EDTA (7,8).

The irrigation solutions and chelating agents are able to change the chemical composition of dentin. For instance, EDTA combined with NaOCl irrigation as final flush and NaOCl alone changed the calcium/phosphorus (Ca/P) ratio of root dentin (9,10).

In the literature, limited data is available concerning the efficacy of QMix solution on chemical composition of root canal dentin. The aim of this study was to evaluate the efficacy of QMix on the removal of smear layer and the Ca/P ratio of root canal dentine after different exposure time periods with scanning electron microscopy (SEM) and an energy-dispersive spectrometer (EDS).

## MATERIAL and METHOD

Sixty freshly extracted, straight, and single rooted mandibular premolar teeth were used. Soft tissue remnants and calculus were removed ultrasonically. The crowns were

removed from cemento-enamel junction with diamond disk (KG Sorensen, Barueri, SP, Brazil). The working length was measured by inserting a #10 stainless steel file (VDW Antaeos, Munich, Germany) with a silicone stop until the tip of the file was visible at the level of the apical foramen. The root canals were enlarged up to a ProTaper Universal F3 (Dentsply Maillefer, Ballaigues, Switzerland) instrument using with the X-Smart-Endomotor (Dentsply Maillefer). Root canals were irrigated with 2 mL 2.5% NaOCl between instrument changes. After the preparation of root canals, the specimens were irrigated with 5 ml of 2.5% NaOCl for 1 min, then divided randomly into 5 groups according to the application time of the QMix solution (n=12). In group 1, no irrigation was performed and defined as control group. The other groups were defined consecutively as follows; QMix solution were used for 1,3,5 and 10 minutes (Group 2,3,4,5). After final irrigation, root canals were irrigated with 2.5 mL distilled water to remove remnants of QMix solution. Longitudinal grooves were prepared on the buccal and lingual root surfaces using a diamond disk. The roots were split into two halves with a small chisel. Half of each specimen was prepared for SEM analysis and the micrographs were taken from apical, middle and coronal thirds of each root canal at 1000X-2000X magnifications.

One blinded observer scored the amount of smear layer and erosion of the dentinal tubules according to the criteria which was used by Torabinejad *et al.* (2003)(11).

Scoring for the remaining smear layer:

- 1: no smear layer (no smear layer on the surface of the root canals; all tubules were clean and open)
- 2: moderate smear layer (no smear layer on the surface of root canal, but tubules contained debris),
- 3: heavy smear layer (the smear layer covered the root canal surface and tubules).

Scoring for root dentine erosion:

- 1: no erosion (all tubules looked normal in appearance and size),
- 2: moderate erosion (the peritubular dentine was eroded),
- 3: severe erosion (the intertubular dentine was destroyed, and tubules were connected with each other). Ca and P levels in the root canal surfaces were measured using SEM and EDS at two different regions of each specimen. According to the weight percent of Ca and P amounts, Ca/P ratio was calculated.

Smear layer scores, erosion scores and Ca/P ratios of each group were recorded and statistically compared. Statis-

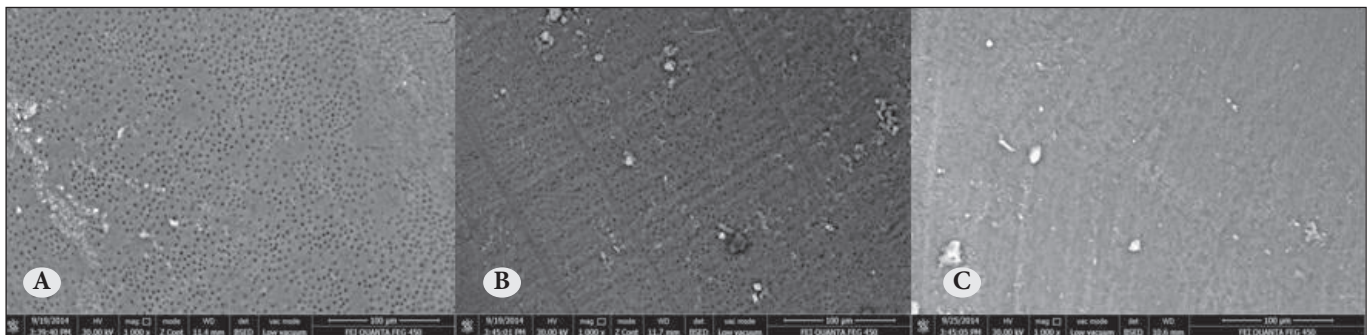
tical analyses were performed with SPSS 19.0 software (SPSS Inc., Chicago, IL, USA). Distribution of data was determined by Shapiro-Wilks test. Continuous variables were expressed as median (minimum-maximum). Differences among the groups were analyzed by the Kruskal-Wallis test. Dual comparisons among groups with significant values were evaluated with the Dunn's test. *P* value of less than 0.05 was considered statistically significant for all tests.

## RESULTS

Figure 1 represents the examples of SEM images and the results of the smear layer scores are shown in Table I. The smear layer scores of control group were signifi-

cantly higher than the 3, 5 and 10 minute groups in all regions ( $P<0.05$ ). The significant differences between control and 1 minute groups were observed in only coronal third ( $P<0.05$ ). In apical and middle regions, smear layer scores of 10 minute group, were significantly lower than 1 minute group ( $P<0.05$ ). There was significant difference between 1 and 5 minute groups in middle third. No peritubular or intertubular erosion was observed and statistical analysis of erosion scores could not be performed, because all groups presented 'score 1' in all thirds of specimens.

Table II presents the Ca/P ratio results of the control group and the other groups, treated with QMix for 1,3,5



**Figure 1:** Representative SEM images with A) score 1: no smear layer; B) score 2: moderate smear layer and C) score 3: heavy smear layer.

**Table I:** The results of the smear layer scores for all groups.

		Mean	N	Std. Deviation	Median	Minimum	Maximum
Apical	Control	3,00	12	,000	3,00	3	3
	1 min	2,33	12	,492	2,00	2	3
	3 min	2,00	12	,426	2,00	1	3
	5 min	1,92	12	,515	2,00	1	3
	10 min	1,50	12	,522	1,50	1	2
Middle	Control	2,92	12	,289	3,00	2	3
	1 min	1,92	12	,289	2,00	1	2
	3 min	1,25	12	,452	1,00	1	2
	5 min	1,17	12	,389	1,00	1	2
	10 min	1,00	12	,000	1,00	1	1
Coronal	Control	2,58	12	,515	3,00	2	3
	1 min	1,17	12	,389	1,00	1	2
	3 min	1,08	12	,289	1,00	1	2
	5 min	1,00	12	,000	1,00	1	1
	10 min	1,00	12	,000	1,00	1	1

**Table II:** The Ca/P ratio results of the control and tested groups.

	N	Mean	Std. Deviation	Minimum	Maximum
<b>Control</b>	24	1,8987	,15916	1,60	2,18
<b>1 min</b>	24	1,8442	,12357	1,63	2,17
<b>3 min</b>	24	1,8192	,15231	1,52	2,14
<b>5 min</b>	24	1,8450	,14539	1,62	2,14
<b>10 min</b>	24	1,7867	,11009	1,63	2,05

and 10 minute time periods. There were no significant differences between all groups ( $P>0.05$ ). Control group showed higher Ca/P ratio than the other groups without significant differences.

## DISCUSSION

The removal of the smear layer from root canal is a controversial issue (2). Some authors suggested that presence of smear layer may block the dentinal tubules and prevent the exchange of bacteria and other irritants by altering permeability (2,12,13). Conversely, some authors reported that smear layer should be removed, since it may reduce the disinfection of dentin tubules by preventing root canal irrigants and medicaments from penetrating dentin tubules (2). Additionally, smear layer also contains bacteria and their by-products and removing this layer increase the efficacy of disinfection and provide better adaptation of root canal filling material (2).

The present study evaluated the efficacy of an actual irrigation solution which may provide both removal of smear layer and root canal disinfection. The antimicrobial performance of QMix was tested by previous studies (14,15). Ma et al. (2011) reported that QMix was equally effective in killing bacteria in dentin as 6% NaOCl; more than 40% and 60% of the bacteria were killed by both at 1 minute and 3 minutes (14). Wang et al. (2012) reported that QMix showed comparable results with 6% NaOCl against young and old *Enterococcus faecalis* biofilms in dentin canals (15). Besides its satisfactory antimicrobial activity, it was reported that ability to remove smear layer by QMix was comparable to EDTA (8,16). Furthermore, Eliot et al. showed that QMix were superior to EDTA in smear layer removal and exposure of dentinal tubules in the root canal system (17). According to the results of previous studies, QMix irrigation solution is an effective solution for cleaning root canal walls (14,15,16,17). However, it is not clear how long the solution should

contact with root canal dentin for efficient smear layer removal without causing erosion. Previous studies used QMix solution in different time periods such as 1,2,3 and 5 minutes (7,15,16,18,19). QMix irrigation solution was applied up to 10 minutes in the present study to evaluate the longer term effect.

The results of the present study showed that QMix solution should be applied at least one minute for coronal third and three minutes for middle third of the root canal for efficient on removal of smear layer. However, in apical third of the root canal, 1,3 and 5 minute groups showed approximately 'score 2' and there were no significant differences among these groups. Only 10 minute exposure time showed significant difference from 1 minute group. Stojicic et al. (2012) reported that QMix and EDTA solutions are able to remove smear layer in 5 minutes with comparable results (8). Stojicic et al. (2012) examined the smear layer removal after cutting off the apical third and then they prepared the specimens by cutting the root canals perpendicularly to the axis of the tooth (8). The results presenting the middle and coronal thirds in the present study were similar with Stojicic et al. (2012). In this study, different from the previous one, the irrigation was performed with the original root canal anatomy and apical third was evaluated additionally. It was demonstrated that more than five minutes was required for removal smear layer in the apical part.

The present study also examined the effect of QMix on root canal walls in terms of dentin erosion. Noteworthy, all scores of the specimens in all groups and regions showed 'score 1', in other words, no erosion were observed after different exposure time periods. The result of the present study was in accordance with Aranda-Garcia et al. (2013) who evaluated the effect of different solutions such as EDTA and QMix on the erosion of root canal dentin and reported that erosion of dentin tubules was promoted by 17% EDTA (20). The previous study used same scoring system for evaluating erosion and



reported 'score 1' as a median and this result is compatible with the present study.

According to the authors knowledge, the Ca/P ratio of root canal dentin after irrigation with QMix was not previously evaluated. The present study showed that irrigation with QMix solution in all time periods did not alter the Ca/P ratio of root canal dentin significantly. Any change in the Ca/P ratio may alter the original ratio of organic and inorganic components, which change dentin permeability, microhardness and solubility (21, 22, 23).

## CONCLUSION

Within the limitations of this study, when coronal, middle and apical thirds were considered, QMix irrigation solution is able to remove smear layer effectively in 10 minutes without causing any erosion in dentinal tubules or alteration in the Ca/P ratio.

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