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Research Article

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Morphological Changes of Radicular Dentin After Exposure to Chelating Agents

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Abstract

Aim: *The purpose of this study was to observe the effect of Q mix root canal irrigant compared to Ethylenediaminetetraacetic acid (EDTA) on radicular dentine with different contact times.*

Materials and Methods: *Ninety single-rooted human teeth were decoronated and instrumented to size 40/taper 0.06. the specimens were randomly allocated to 3 groups. In the control group (n=20), canals were irrigated with 3ml distilled water. In group 2 (n= 40), canals were irrigated with 3ml of 17% EDTA+ NaOCl, and further subdivided into group 2A (n=20) with a contact time of the 60s, and group 2B (n= 20) with a contact time of 90s. In group 3 (n=40), canals were irrigated with 3ml Q mix+ NaOCl, and subdivided into; Group 3A (n=20) with the 60s and 90s contact time respectively. After irrigation, the canals were rinsed with 5 mL saline. The coronal orifice and apical foramen were sealed, and the roots were split into two halves. The coronal, middle and apical parts were examined with a Scanning Electron Microscope (SEM) at 3000x magnification to evaluate the smear layer. Two-way ANOVA was used for analysis with statistical significance set at 0.05.*

Results: *EDTA + NaOCl with a 90 seconds exposure time was found to be more efficient in removing the smear layer in comparison to both EDTA + NaOCl with at 60 seconds exposure time and Qmix + 5.25% NaOCl with at 90 seconds irrigation in both cervical and middle one-third root regions. The interactive effect of irrigation regimens and radicular dentine area were not found to be significant.*

Conclusion: *Both irrigation methods were equally efficient in eliminating the smear layer with different contact time. However, SEM revealed that the combination of EDTA+ NaOCl with a 90 seconds contact time had more erosion effect on the dentinal wall.*

Keywords: Qmix, EDTA, Irrigation Solution, Radicular Dentin, Dentinal Erosion, Smear Layer, Sem, Endodontics.

Introduction

A smear layer of variable thickness usually forms during root canal instrumentation, especially with use of rotary instruments, which covers dentinal tubules and fills root canal irregularities [1, 2]. This layer is made up of dentin particles, inorganic debris, and organic materials such as blood cells, bacteria (and their by-products), and pulp tissue remnants [3]. Due to this morphology and composition, it is deemed essential to remove the smear layer during root canal instrumentation to adequately expose the dentinal tubules for effective disinfection of the root canal to occur [3]. Solutions with a combination of NaOCl and EDTA have been suggested as irrigants to effectively rid the root canal wall of the smear layer [4, 5]. However, this regimen might lead to dentinal surface erosion [4]. Extended exposure to EDTA might also lead to decreased flexure strength and modulus of elasticity of dentin, which may affect the mechanical and physical properties of dentin, increasing the risk of root fracture [4].

QMix 2in1 Irrigating Solution (Dentsply Tulsa Dental Specialties, Tulsa, OK) is a novel endodontic irrigant containing EDTA, chlorhexidine gluconate, and a non-specified detergent that has been shown to be as effective as 17% EDTA in removing the smear layer [6]. QMiX is a clear solution, ready to use with no chair-side mixing). It is recommended as final rinse after NaOCl. Despite Mixing EDTA and CHX is known to produce a white precipitate, the CHX content, mixing QMiX with sodium hypochlorite does not produce any precipitate (data not shown) and the solution does not turn brown/orange [7].

This study was conducted evaluate the effect of QMix as compared to EDTA on radicular dentine, when used as a final irrigation protocol with different exposure times. The null hypothesis was that there is no significant difference between the two with different exposure times.

Materials and MethodsTeeth Collection and Preparation

This randomized controlled in vitro study has received exemption from the Internal Review Board at Princess Nourahbint Abdulrahman University No. (H-01-R-059).

Ninety single-rooted human teeth with closed apex were included in this study. Teeth with caries, cracks, and dilacerations were excluded. The teeth were decoronated with a diamond bur (Meisinger, Germany), and roots were standardized at length 15mm. The canals were shaped with Pro Taper nickel-titanium rotary instruments (Dentsplymailefer, Switzerland) till size #40k with a 0.06 taper according to manufacturer instructions, and (3ml)5.25 % NaOCl (Diaa,KSA) was used for irrigation.

Specimen Preparation

The samples were allocated to 3 groups. Group 1 (the control group) included 20 teeth, which were instrumented and irrigated with 3ml distal water. Group 2 included 40 teeth that were irrigated using a of total 3ml 17% EDTA (Dental Grade, Switzerland) mixed with 3 ml of NaOCl (Diaa, KSA), this group was further subdivided to 20 samples (Group 2A), which were exposed to 60 seconds contact time, and 20 samples (Group 2B) which were subjected to 90 seconds exposure time. Group 3 included 40 teeth that were irrigated with 3ml of QMix (Dentsply, Germany) mixed with 3ml of NaOCl (Diaa, KSA), and further subdivided into 20 samples (Group 3A) which were exposed to 60 seconds contact time, and 20 samples (Group 3B) which were subjected to 90 seconds exposure time. The canals were given a final rinse with 5ml sterile water after the experimental exposure time (60 seconds or 90 seconds) to exclude any excess debris and/or solution.

Scanning Electron Microscope (SEM) Evaluation

The coronal and apical foramens of each specimen were sealed using packed composite shade A1 (3M ESPE, Germany) without acid etch nor bonding agent. The specimens were then grooved longitudinally and split into two halves with a hammer and chisel. The specimens were fixed for SEM (JEOL 6060LV, Japan) using potassium phosphate buffer, 2% glut aldehyde (Snow. China) ,30%, 60% and 100% acetone (SYDNEY, Canada). The specimens were examined at 3000x magnification to assess the smear layer. Each sample had 3 images taken at the coronal, middle and apical part. Each image was analyzed for the presence of smear layer, debris and erosion. A visual examination was performed by three investigators and scoring was performed from 0-3 where "0" meant null, "1" meant low, "2" meant medium and "3" meant high. Inter- and intra-examiner reliability was performed to validate collected data.

Statistical Analysis

Two-way analysis of variance (ANOVA) statistical test using SPSS version 21.0 was used to evaluate the statistical differences between the groups. Furthermore, post hoc Tukey's test was evaluated for pairwise comparison between the study groups.

Results

Both irrigation regimens and radicular dentine area had a significant effect on the smear layer, P=0.000 and P=0.030, respectively (Table1). Moreover, their interactive effect was significant (P=0.046).

Table 1: The results of two-way ANOVA for the differences in removing the smear layer among the tested groups.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	66.169a	14	4.726	6.855	.000
Intercept	173.166	1	173.166	251.137	.000
Irrigation regime	50.723	4	12.681	18.390	.000
Radicular dentine area	4.890	2	2.445	3.546	.030
Irrigation regime * Radicular dentine area	11.102	8	1.388	2.013	.046
Error	169.624	246	.690		
Total	386.000	261			
Corrected Total	235.793	260			

In all the radicular regions, statistical differences were apparent between control and (EDTA + NaOCl 90s) ($P < 0.05$). Furthermore, (EDTA + NaOCl 90s) were found to be more efficient in eliminating the smear layer in comparison to (EDTA + NaOCl 60s) and (Qmix + NaOCl 90s) irrigation regimes in both cervical and middle one-third regions. However, (EDTA + NaOCl 90s) was found to be more effective in removing the smear layer compared to the control group in apical one-third region (Table 2).

Table 2: Tukey's post hoc pairwise comparison table (for smear layer) showing statistical differences only among the tested groups in relation to radicular dentine region

Area	group	Comparative groups	P value
	Control	EDTA + NaOCl 90 s	0.013
	EDTA + NaOCl 60 s	EDTA + NaOCl 90 s	0.009
	EDTA + NaOCl 90 s	Control	0.013
		EDTA + NaOCl 60 s	0.009
		Qmix + NaOCl 90 s	0.002
	Qmix + NaOCl 90 s	EDTA + NaOCl 60 s	0.002
Middle one-third	Control	EDTA + NaOCl 90 s	0.000
		Qmix + NaOCl 60 s	0.003

	EDTA + NaOCl 60 s	EDTA + NaOCl 90 s	0.000
		Qmix + NaOCl 60 s	0.001
	EDTA + NaOCl 90 s	Control	0.000
		EDTA + NaOCl 60 s	0.000
		Qmix + NaOCl 90 s	0.036
	Qmix + NaOCl 60 s	Control	0.003
		EDTA + NaOCl 60 s	0.001
	Qmix + NaOCl 90 s	EDTA + NaOCl 90 s	0.036
Apical one-third	Control	EDTA + NaOCl 60 s	0.029
		EDTA + NaOCl 90 s	0.000
	EDTA + NaOCl 60 s	Control	0.029
	EDTA + NaOCl 90 s	Control	0.000
	Qmix + NaOCl 90 s	EDTA + NaOCl 90 s	0.013

Table 3: The results of two-way ANOVA for the differences in effectiveness of debris removing among the tested groups.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	24.937a	14	1.781	3.390	.000
Intercept	177.082	1	177.082	336.985	.000
Irrigation regime	20.209	4	5.052	9.615	.000
Radicular dentine area	.657	2	.329	.626	.536
Irrigation regime * Radicular dentine area	4.107	8	.513	.977	.455
Error	129.270	246	.525		
Total	364.000	261			
Corrected Total	154.207	260			

Irrespective of the radicular dentine region, all irrigation regimes were found to be effective in removing the debris.

All the experimental irrigation regimes were found to be effective in removing the debris from entire radicular regions. However, the control irrigation regime was observed to be less effective in removing the debris compared to other experimental irrigation regimes (Table 4).

Area	group	Comparative groups	P value
Cervical one-third	EDTA + NaOCl 60 s	Qmix + NaOCl 90 s	0.012
	EDTA + NaOCl 90 s	Qmix + NaOCl 90 s	0.000
	EDTA + NaOCl 90 s	Qmix + NaOCl 90 s	0.000
		EDTA + NaOCl 60 s	0.009
		Qmix + NaOCl 90 s	0.002
Middle one-third	EDTA + NaOCl 60 s	Qmix + NaOCl 90 s	0.008
	Qmix + NaOCl 90 s	EDTA + NaOCl 60 s	0.008
Apical one-third	EDTA + NaOCl 60 s	Qmix + NaOCl 60 s	0.037
		Qmix + NaOCl 90 s	0.016
	Qmix + NaOCl 60 s	EDTA + NaOCl 60 s	0.037
	Qmix + NaOCl 90 s	EDTA + NaOCl 60 s	0.016

Table 5: The results of two-way ANOVA for the differences in causing erosion to dentinal tubules due to irrigation regime among the tested groups.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	21.277a	14	1.520	2.055	.015
Intercept	46.113	1	46.113	62.341	.000
Irrigation regime	14.569	4	3.642	4.924	.001

Radicular dentine area	1.751	2	.876	1.184	.308
Irrigation regime * Radicular dentine area	5.306	8	.663	.897	.520
Error	181.964	246	.740		
Total	267.000	261			
Corrected Total	203.241	260			

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