

## **EFFICACY OF DIFFERENT IRRIGATING SYSTEMS WITH A NEW IRRIGATING SOLUTION IN REDUCING INTRACANAL *ENTEROCOCCUS FAECALIS***

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### **ABSTRACT**

**Aim:** The aim of the present study was to evaluate the effect of QMix<sup>TM</sup>2in1 in comparison with sodium hypochlorite irrigating solution on *Enterococcus faecalis* using different irrigation systems namely: Passive irrigation, ultrasonic activation, sonic activation.

**Materials and methods:** 70 freshly extracted human single rooted teeth were collected. Root canals were prepared using Protaper Universal NiTi rotary file system in a crown down technique. Enterococcus Faecalis bacterial suspension in Trypticase soy broth was applied into the canal of each root. 65 Teeth were randomly divided into 3 experimental groups of 20 teeth each according to the technique used during irrigation protocol and a control group of 5 teeth without irrigation. Each group was subdivided into two sub-groups according to the type of irrigant. Samples were divided into four time intervals; S1 sample was taken immediately after infection of the teeth, S2 sample was taken immediately after irrigation, S3 sample was taken after 3 days incubation period after irrigation of the teeth, S4 sample was taken after 10 days from the infection. The method of evaluation of antimicrobial activity used was direct counting of colony forming units (CFUs) after irrigation.

**Results:** there was increase in the bacterial count reduction with no statistical difference between QMix<sup>TM</sup>2in1 and 2.5% NaOCl after 3 days period from the irrigation procedures, while there was increase in the effect of QMix<sup>TM</sup>2in1 over 2.5% NaOCl after 10 days from irrigation procedures. While there wasn't any difference found between the three agitation techniques on the antibacterial activity of both irrigants used.

**Conclusions:** QMix<sup>TM</sup>2in1 irrigating solution proved antimicrobial efficacy in short and prolonged duration against *Enterococcus faecalis*. The antimicrobial efficiency of sodium hypochlorite can be improved using full concentration. It was also concluded that different agitation techniques have no effect on the antimicrobial efficacy.

**KEYWORDS:** Irrigation, *Enterococcus faecalis*, QMix<sup>TM</sup>2in1, Max-I-probe, Endoactivator, ultrasonic activation.

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## INTRODUCTION

Many microorganisms are able to form surface-attached microbial communities, known as biofilms. Biofilms can be defined as communities of microorganisms attached to a surface and embedded in a matrix of polysaccharides and proteins forming a slimy layer. The matrix takes 85% of the volume of biofilm <sup>(1,2)</sup>. *Enterococcus faecalis* regarding its role in root canal treatment failure where it is a microorganism commonly detected in asymptomatic, persistent endodontic infections <sup>(3)</sup> Irrigants are essential for successful debridement of the root canals <sup>(4)</sup>. Sodium hypochlorite (NaOCl) has been widely used as an irrigant since its introduction in endodontics. The antimicrobial activity of NaOCl has been shown by several studies <sup>(5-7)</sup>. Another new antimicrobial root canal irrigant QMixTM2in1 containing a mixture of a bisbiguanide antimicrobial agent, a polyamino-carboxylic acid, calcium-chelating agent, and a surfactant have been found to be effective against bacterial biofilms have been found to be effective against bacterial biofilms <sup>(8)</sup>. All irrigants must be brought into direct contact with the entire canal wall for effective action <sup>(9)</sup>. *Tronstad et al* <sup>(10)</sup> were the first to report the use of a sonic instrument for endodontics in 1985. One of the recent sonic driven canal irrigation devices is the endoactivator system that uses sonic energy to irrigate root canal systems <sup>(11)</sup>. *Richman* <sup>(12)</sup> was the first to describe the use of ultrasonics for cleaning the root canal. Ultrasonic devices operate between 25-40 kHz transforming electrical and electromagnetic energy into mechanical energy. The term Passive ultrasonic irrigation (PUI) was first used by *Weller* <sup>(13)</sup>. Accordingly, a study comparing the antimicrobial effect of the previously mentioned irrigants using different activation protocols may enlighten our knowledge.

## MATERIALS AND METHODS

70 freshly extracted human single rooted teeth were collected. Root canals were prepared using Protaper Universal NiTi rotary file system (Dentsply

Maillefer, Ballaigues, Switzerland) in a crown down technique. A strain of *Enterococcus faecalis* (ATCC 29212) (Central Health Laboratories, Cairo) was used as a tested organism. Morphological figures on M-Enterococcus agar plates were formed. They appeared as pink rounded colony growth, and microscopically using gram staining technique. The Isolated 24-hours colonies of pure culture of *Enterococcus faecalis* were suspended in 20 ml of trypticase soy broth TSB (Oxoid Ltd, Basingstoke, United Kingdom.) and incubated for 24 hours at 37°C until the optical density of the bacterial suspension was adjusted to approximately  $3 \times 10^8$  CFU/ml, by comparing its turbidity to 1 McFarland standard.

Under aseptic conditions, 10  $\mu$ l of the previously prepared bacterial suspension was applied into the canal of each root using an automatic Eppendorf micropipette (Kopenicker, Bad Durkheim, Germany). The coronal access of all samples were sealed with pink wax and enclosed individually within sterile Eppendorf tubes (Elkay, Shrewbury, MA, USA) held vertically in a perforated tray. They were incubated at 37°C for seven days to give time for bacteria to infiltrate deeply within the dentinal tubules. 10  $\mu$ l of sterile TSB was added on the third day during the incubation period, to maintain bacterial survival, overcome dehydration and to maintain a constant source of nutrition for the bacteria.

### The first sample for bacterial count (S1):

After seven days of incubation period the wax of the coronal access was removed and the first sample (S1) was taken as follows: Sterile 1.5ml Eppendorf tubes containing 1ml saline were previously prepared and labelled corresponding to the sample number. 20  $\mu$ l of sterile saline was taken by sterile filter tips\* mounted using an automatic micropipette from each labelled Eppendorf. Tips are applied and the saline is washed several times inside the root canal of the suggested sample. Dispersion of saline solution back in the previously labelled Eppendorf

is done. This procedure is done several times for all S1 samples. For each sample 100  $\mu$ l was streaked on agar plates. For uncounted sample one excess step was performed as 10  $\mu$ l taken from the previous sample is diluted on 1  $\mu$ l sterile saline then 100  $\mu$ l is streaked on the agar plates.

Colony forming units (CFU) was used to determine the number of viable bacterial cells in a sample per ml. This was done by using a small amount of a liquid culture and plating out several serial dilutions onto culture plates Petri dishes containing M- Enterococcus agar medium). After 3 days incubation period in appropriate conditions for Enterococcus faecalis, the colonies grown were counted.

#### **A. Grouping of teeth according to the mode of irrigation:**

Sixty five samples were randomly divided into 4 groups (n=20) each according to the irrigation technique used:

- Group A: were irrigated using Max-I-Probe (Dentsply-Rinn, Elgin, IL), (n=20).
- Group B: were irrigated using Endoactivator (Dentsply Tulsa Dental Specialities, Tulsa, Ok), (n=20).
- Group C: were irrigated using Ultrasonic device (Acetone Group, Merigance Codex, France), (n=20).
- Group D: control group didn't receive any type of irrigation (n=5).

Each group is equally subdivided into two subgroups (each n=10) according to the irrigant used as follows:

- Subgroup (A<sub>1</sub>, B<sub>1</sub>, and C<sub>1</sub>): irrigation was done with 2.5% NaOCl (Oxford Laboratory, Mumbai, Maharashtra, India).
- Subgroup (A<sub>2</sub>, B<sub>2</sub>, and C<sub>2</sub>): irrigation was done with QMix™2in1 (DentsplyTusla Dental Specialities, Oklahoma, USA) full concentration.

#### **1. Irrigation Protocol of group A (Max-I-Probe) (n=20)**

Specimens in subgroup (A1) (2.5% NaOCl) were subjected to, a three cycles 20 seconds each as follows:

First- 20 seconds cycle: teeth were irrigated using 30-gauge side vented needle mounted on a syringe. The syringe was filled with the irrigating solution and the needle was introduced in the canal without wedging and evacuated with light hand pressure. The other two cycles was performed as the first cycle with a total volume of 3ml for 1 min. Specimens in subgroup (A2) (QMix™2in1) were subjected to three cycles 20 seconds each as previously mentioned.

#### **2. Irrigation protocol of group B (Endoactivator) (n=20)**

Specimens in subgroup (B1) (2.5% NaOCl) were subjected to three activation cycles 20 seconds each as follows:

First 20 seconds cycle: teeth were irrigated with 1ml (2.5%NaOCl) followed by activation with the Endoactivator at 10,000 cycles per minute with a #25/04 polymer tip(Dentsply Tulsa Dental Specialities, Tulsa, Ok ) placed 1mm shorter than the working length. A new sterile tip was used for each sample. The other two cycles was performed as the first cycle with a total volume of 3ml for 1 min. Specimens in subgroup (B2) (QMix™2in1) were subjected to three activation cycles 20 seconds each as previously mentioned.

#### **3. Irrigation protocol of group C (ultrasonic) (n=20)**

Specimens in subgroup (C1) (2.5% NaOCl) were subjected to three activation cycles 20 seconds each as follows:

First 20 seconds: teeth were irrigated with 1ml (2.5% NaOCl) then activated by Irrisafe ultrasonic tip (Acetone Group, Merigance Cedex, France)

mounted on Satelec ultrasonic device at power setting of 5 placed 1mm shorter than the working length. A new sterile tip was used for each sample. The other two cycles was performed as the first cycle with a total volume of 3ml for 1 min. Specimens in subgroup (C2) (QMix™2in1) were subjected to three activation cycles 20 seconds each as previously mentioned.

#### **The second sample for bacterial count (S2):**

Immediately after irrigation procedures the second sample for bacterial count (S2) was taken from each root canal by the same way as in S1 then aliquots (drops) of 0.1 ml were plated onto M-Enterococcus agar plates and incubated at 37°C for 48h. The appearance of red colonies represented the colonies of viable *Enterococcus faecalis* which were counted and recorded.

#### **The second incubation period:**

After the second sample for bacterial count was taken each root canal was filled with 20 µl sterile TSB and the coronal access was sealed with melted pink wax and all the samples were enclosed individually within sterile Eppendorf tubes and held vertically in a perforated rack. They were incubated at 37°C for three days.

#### **The third sample for bacterial count (S3):**

After three days incubation period the third sample for bacterial count (S3) of each root canal was taken by the same way as in S1 and S2 and data obtained from S3 were also counted and recorded.

#### **The third incubation period:**

After the third sample for bacterial count was taken each root canal was filled with 20 µl sterile TSB and the coronal access was sealed with melted pink wax and all the samples were enclosed individually within sterile Eppendorf tubes and held vertically in a perforated rack. They were incubated at 37°C for another seven days to check the prolonged action

of the irrigating solutions after 10 days from the irrigation procedures.

#### **The fourth sample for bacterial count (S4):**

After seven days incubation period the fourth sample for bacterial count (S4) of each root canal was taken by the same way as in S1, S2 and S3 data obtained from S4 were also counted and recorded.

Colony forming units (CFU) were calculated based on surface streaking inoculation using sterile cotton swab.

#### **Counting the resulting bacterial colonies.**

After appropriate incubation, plates were inspected and growth on the plates was reflected to the dilution. There were heavy plates and countable plates.

Each petri dish was divided into 4 equal squares and the number of bacteria was counted for one square and then multiplied x4 to estimate whole plate colony forming unit count. Countable limit of this procedure was 30 to 300 colonies per plate.

Counting was performed in the presence of magnifying light using a colony counter that counts by touching the agar directly and gives two signals an audible and a black dot on the plate and appearance of the colony numbers that was counted on the display.

The number and percentage of the positive cultures (turbid) and whole plate CFU count for each sample at each determined period were collected, recorded, tabulated and subjected to statistical analysis using Kruskal-Wallis, Mann-Whitney U, Friedman's and Wilcoxon signed-rank tests.

## **RESULTS**

The following results represented the efficacy of three irrigation devices Max-I-Probe, Endoactivator and ultrasonic using 2.5% NaOCl and QMix™2in1 in reducing intracanal *Enterococcus faecalis* at

different time intervals. The time intervals were immediately after irrigation of the samples, three days after irrigation and ten days after irrigation.

**Comparison between changes in bacterial counts by time within Max-I-Probe group using two irrigating solutions (2.5% NaOCl and QMix™2in1).**

Friedman’s and Wilcoxon signed-rank statistical analysis compared changes in the mean bacterial count by time from (S1) to (S2) as well as from (S3) to (S4) within Max-I-Probe group using two irrigants (2.5% NaOCl and QMix™2in1).

When using 2.5% NaOCl irrigating solution (S4) recorded mean bacterial count (9.05 ± 0.08) followed by (S1) (8.98 ± 0.11), (S3) (3.88 ± 2.68) then (S2) (0.00 ± 0.00) that showed no mean

bacterial count. There was a statistically significant decrease in mean bacterial counts when using 2.5% NaOCl from (S1) to (S2). From (S2) to (S3) as well as from (S3) to (S4) there was a statistically significant increase in mean bacterial counts as shown in table (1).

When using QMix™2in1 irrigating solution (S1) showed the highest mean bacterial count (8.99 ± 0.10) followed by (S4) (4.38 ± 3.07), (S3) (1.17 ± 2.47) then (S2) (0.00 ± 0.00) that showed no bacterial count. There was a statistically significant decrease in mean bacterial counts when using QMix™2in1 irrigating solution from (S1) to (S2). From (S2) to (S3), there was no statistically significant change in mean bacterial counts. From (S3) to (S4) there was a statistically significant increase in mean bacterial counts as shown in table (1) and Fig. (1).

TABLE (1) Comparison between changes in mean bacterial counts by time within Max-I-Probe group using two irrigating solutions (2.5%NaOCl and QMix™2in1).

<i>Irrigant</i>	<i>S1</i>	<i>S2</i>	<i>S3</i>	<i>S4</i>
<b>2.5% NaOCl</b>	8.98 ± 0.11 <sup>a</sup>	0.00 ± 0.00 <sup>c</sup>	3.88 ± 2.68 <sup>b</sup>	9.05 ± 0.08 <sup>a</sup>
<b>QMix™2in1</b>	8.99 ± 0.10 <sup>a</sup>	0.00 ± 0.00 <sup>c</sup>	1.17 ± 2.47 <sup>c</sup>	4.38 ± 3.07 <sup>b</sup>

Significant at  $P \leq 0.05$ .

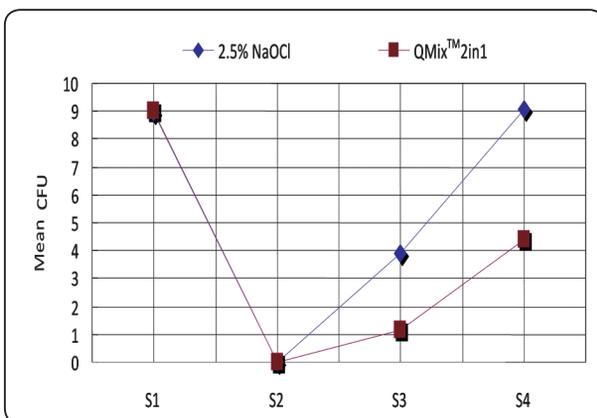


Fig. (1) Comparison between changes in mean bacterial counts by time within Max-I-Probe group using two irrigation solutions (2.5% NaOCl and QMix™2in1).

**Comparison between changes in bacterial counts by time within ultrasonic group using two irrigation solutions (2.5% NaOCl and QMix™2in1).**

Friedman’s and Wilcoxon signed-rank statistical analysis compared changes in the mean bacterial count by time from (S1) to (S2) as well as from (S3) to (S4) within Ultrasonic group using two irrigants (2.5% NaOCl and QMix™2in1).

When using 2.5% NaOCl (S1) showed the highest mean bacterial count (9.01 ± 0.10) followed by (S4) (9.00 ± 0.09), (S3) (2.53 ± 3.27) then (S2) (0.00 ± 0.00) that showed no mean bacterial count. There was a statistically significant decrease in

mean bacterial counts when using 2.5% NaOCl irrigating solution from (S1) to (S2). From (S2) to (S3) as well as from (S3) to (S4) there was a statistically significant increase in mean bacterial counts as shown in table (2).

When using QMix™2in1 irrigating solution (S1) showed the highest mean bacterial count (9.01 ± 0.10) followed by (S4) (4.10 ± 2.84), (S3) (1.10 ± 2.32) then (S2) (0.00 ± 0.00) that showed no mean bacterial count. There was a statistically significant decrease in mean bacterial counts when using QMix™2in1 irrigating solution from (S1) to (S2). From (S2) to (S3), there was no statistically significant change in mean bacterial counts. From (S3) to (S4) there was a statistically significant increase in mean bacterial counts as shown in table (2) and Fig. (2).

**Comparison between changes in bacterial counts by time within Endoactivator group using two irrigating solutions (2.5% NaOCl and QMix™2in1).**

Friedman’s and Wilcoxon signed-rank statistical analysis compared changes in the mean bacterial count by time from (S1) to (S2) as well as from (S3) to (S4) within Endoactivator group using two irrigating solutions (2.5% NaOCl and QMix™2in1).

When using 2.5% NaOCl (S4) recorded the highest mean bacterial count (9.01 ± 0.09) followed by (S1) (8.98 ± 0.09), (S3) (2.22 ± 2.88) then (S2) (0.00 ± 0.00) that showed no mean bacterial count. There was a statistically significant decrease in mean bacterial counts when using 2.5 % NaOCl irrigating solution from (S1) to (S2). From (S2) to (S3) as

TABLE (2) Comparison between changes in mean bacterial counts by time within ultrasonic group using two irrigating solutions (2.5% NaOCl and QMix™2in1).

<i>Irrigant</i>	<i>S1</i>	<i>S2</i>	<i>S3</i>	<i>S4</i>
<b>2.5% NaOCl</b>	9.01 ± 0.10 <sup>a</sup>	0.00 ± 0.00 <sup>b</sup>	2.53 ± 3.27 <sup>b</sup>	9.00 ± 0.09 <sup>a</sup>
<b>QMix™2in1</b>	9.01 ± 0.10 <sup>a</sup>	0.00 ± 0.00 <sup>c</sup>	1.10 ± 2.32 <sup>c</sup>	4.10 ± 2.84 <sup>b</sup>

Significant at  $P \leq 0.05$ .

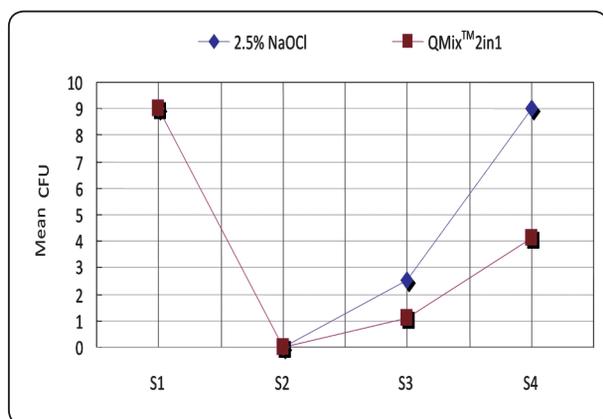


Fig. (2) Comparison between changes in mean bacterial counts by time within ultrasonic group using two irrigating solutions (2.5% NaOCl and QMix™2in1).

well as from (S3) to (S4) there was a statistically significant increase in mean of bacterial counts as shown in table (3).

When using QMix™2in1 irrigating solution (S1) recorded the highest mean bacterial count (8.98 ± 0.09) followed by (S4) (4.27 ± 2.99), (S3) (1.14 ± 2.40) then (S2) (0.00 ± 0.00) that showed no mean bacterial count. There was a statistically significant decrease in mean bacterial counts when using QMix™2in1 irrigating solution from (S1) to (S2). From (S2) to (S3), there was no statistically significant change in mean bacterial counts. From (S3) to (S4) there was a statistically significant increase in mean bacterial counts as shown in table (3) and Fig. (3).

TABLE (3) Comparison between changes in mean bacterial counts by time within Endoactivator group using two irrigating solutions (2.5% NaOCl and QMix™2in1).

Irrigant	S1	S2	S3	S4
2.5% NaOCl	8.98 ± 0.09 <sup>a</sup>	0.00 ± 0.00 <sup>b</sup>	2.22 ± 2.88 <sup>b</sup>	9.01 ± 0.09 <sup>a</sup>
QMix™2in1	8.98 ± 0.09 <sup>a</sup>	0.00 ± 0.00 <sup>c</sup>	1.14 ± 2.40 <sup>c</sup>	4.27 ± 2.99 <sup>b</sup>

Significant at  $P \leq 0.05$ .

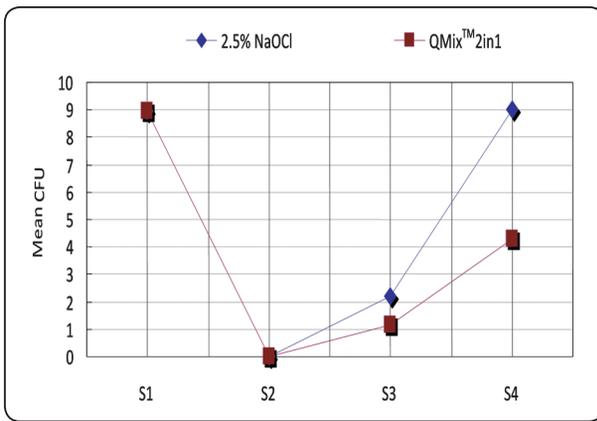


Fig. (3) Comparison between changes in mean bacterial counts by time within Endoactivator group using two irrigating solutions (2.5% NaOCl and QMix™2in1).

**DISCUSSION**

Successful endodontic treatment depends mainly on proper cleaning, shaping and obturation of the root canal system. Earlier researches<sup>(1)</sup> placed great emphasis on the bacterial contamination of the root canal as it is a major concern in endodontics. Elimination of microorganisms and necrotic tissues from the root canal system is essential for successful treatment outcome. The complexity of the root canal system as well as limitations of the used root canal irrigants makes this job difficult if not impossible. Some bacteria may remain in the far reached irregular areas of the root canal system as well as within the dentinal tubules, where they grow in the form of aggregates embedded in extracellular matrix material known as biofilm<sup>(2)</sup>.

Wang et al<sup>(14)</sup> concluded that within root canals, bacteria in established biofilm are less likely killed

by endodontic irrigation and medication than bacteria in young biofilm.

In our present study *Enterococcus faecalis* microorganism was selected as it exhibits different characteristics as being gram-positive, nonspore-forming cocci that occur singly, in pairs, and in short chains. It is a facultative anaerobe and is found adapted to the complex environments of the oral cavity. *Enterococcus faecalis* has been occasionally detected in primary root canal infections<sup>(15)</sup>. Researchers reported that *Enterococcus faecalis* can be found in several cases of persistent infections, including failed cases. It is apparent from the dental literature that *Enterococcus faecalis* often is difficult to eradicate with current intracanal medications<sup>(16,17)</sup>.

Historically, countless compounds in aqueous solution have been suggested as root canal irrigants. Thus, the purpose of this study was to evaluate the effect of 2.5% sodium hypochlorite in comparison with QMix™2in1 irrigating solution on *Enterococcus faecalis* using different irrigation systems namely: Passive irrigation, ultrasonic activation and sonic activation.

Sodium hypochlorite was chosen as an irrigant in the present study because it is the most widely accepted irrigant due to its effective antibacterial action, dissolution of organic materials and ease of removal from the canal. However, at high concentrations it is toxic and irritates the periapical tissues<sup>(18)</sup>.

The second selected irrigant is a new antimicrobial root canal irrigant QMix™2in1 that

have been found to be effective against bacterial biofilms<sup>(8)</sup>. Multiple studies have shown superior antimicrobial effect of QMix™2in1 together with its ability in smear layer removal<sup>(19-22)</sup>.

Currently several techniques and systems are available and reported to improve final irrigation before obturation. Among these protocols: Irrigation with needles, Manual dynamic agitation, Endoactivator, passive ultrasonic irrigation, all shown promising results on debris and smear layer removal<sup>(23)</sup>. There is a debate in literature about the action of these systems in eradication of microorganism<sup>(9,24,25)</sup>.

The results of our study regarding the antibacterial effect of both of the testing solutions with different agitation protocols came with increase in the bacterial count reduction with no statistical difference between QMix™2in1 and 2.5% NaOCl after 3 days period from the irrigation procedures. This finding is in full agreement with the study conducted by *Ma et al*<sup>(19)</sup>. The current study used a methodology that mimics more the clinical environment.

Furthermore, our results came in agreement with the work of *Stojicic S et al*<sup>(20)</sup> who used lower concentration of NaOCl (1%) and tested different time intervals of application 5 seconds, 30 seconds and 3 minutes. *Wang et al*<sup>(14)</sup> compared the antibacterial effect of QMix™2in1 to 6% NaOCl on young and old *Enterococcus faecalis* biofilms. They found that both irrigants were as effective in killing young *Enterococcus faecalis* biofilms. The results of their studies also agree with the present study.

These findings disagree with the results reached by *Morgental et al*<sup>(26)</sup> who compared the antimicrobial effect of 6% NaOCl and QMix™2in1 in the presence of dentine powder, results proved that 6% NaOCl was more effective than QMix™2in1 against *Enterococcus faecalis*.

The difference in results might be attributed to the techniques used in infection or different

strains of *Enterococcus faecalis* used as well as the concentration of initial bacterial inoculum. The latter study used bovine dentin that may have caused difference due to its buffering effect.

The results of the present study also showed increasing the effect of QMix™2in1 over 2.5% NaOCl after 10 days of incubation period of microorganisms from the irrigation procedures. This finding is in agreement with *Wang et al*<sup>(27)</sup> who examined the effect of smear layer of infected dentin blocks with *Enterococcus faecalis* on the antibacterial effect of 2%, 6% NaOCl, 2% CHX and QMix™2in1. Results showed the superiority of QMix™2in1 in its antibacterial action against 2% NaOCl. Moreover *Neglia et al*<sup>(28)</sup> and *Tirali et al*<sup>(29)</sup> recorded that sodium hypochlorite has a low antimicrobial efficiency against *Enterococcus Faecalis*, they also added that increasing sodium hypochlorite concentration increases the antimicrobial properties.

Results may be attributed to ability of QMix™2in1 at 10 minutes to remove much of the smear layer and this produces a gradually increasing effect on the dentine bacteria by a synergistic effect of its antibacterial components. The killing by QMix™2in1 increased more than 100% whereas the killing by 2% and 6% NaOCl increased only by 10%. These findings disagree with results reached by *Ma et al*<sup>(19)</sup>, *Stojicic S et al*<sup>(20)</sup>, *Wang et al*<sup>(14)</sup> who stated that QMix™2in1 is as effective as NaOCl in bacterial eradication. Difference in results may be attributed to difference in methodology between the previous studies that subjected the samples to 5 seconds, 30 seconds, 3 minutes and 5 minutes exposure to different irrigating solutions and the current study in which the exposure was only for 1 minute with replenishment every 20 seconds. Furthermore, samples of this study were taken at different time intervals to determine its prolonged efficacy of the tested irrigants.

Results of this study showed that as regarding total mean values of all final rinse techniques, no significant difference was found between the three

techniques i.e. there wasn't any difference between different agitation techniques on the antibacterial activity of both irrigants used. These results agree with the results of several studies, *Brito et al*<sup>(9)</sup> who found that there was no statistically significant difference between conventional irrigation with Max-I-probe needles and activation of the irrigant by the Endoactivator system in intracanal bacterial reduction. *Townsend and Maki*<sup>(25)</sup>, recorded no statistical difference between conventional irrigation and EndoVac in bacterial eradication but there was statistical significant difference for the Ultrasonic, Endoactivator, F-File, and sonic agitation groups.

Furthermore, our results coincided with the work of *Bhuva et al*<sup>(30)</sup> who showed no statistically significant difference when comparing the efficacy of passive ultrasonic irrigation with that of conventional syringe irrigation with 1% sodium hypochlorite on intra-radicular *Enterococcus faecalis* biofilms.

These results disagree with *De Gregorio et al*<sup>(31)</sup> who demonstrated that needle irrigation alone showed significantly less penetration of irrigant that was limited to the level of penetration of the needle in comparison with sonic and ultrasonic. Furthermore, our results contradicted with the work of *Cachovan et al*<sup>(32)</sup> who revealed that ultrasonic activated irrigation reduced bacterial counts significantly better than hydrodynamic irrigation and manual rinsing with NaOCl. These differences between our studies and other studies may be attributed to the limitation of irrigation with the needle 2 to 3 mm beyond the needle tip which may minimize the cleaning efficacy of the manual irrigation making it insufficient to remove the intracanal bacteria compared to sonic and ultrasonic. Furthermore the acoustic streaming velocity and cavitation, which positively influence debris removal and ensures better penetration of different irrigants in to dental tubules.

The present observation in our study suggest that irrigation with QMix™2in1 is as efficient as 2.5%

NaOCl in short duration as well as the prolonged superiority of QMix™2in1 over 2.5% NaOCl. Moreover Agitation using different techniques did not significantly improve the antimicrobial efficiency of the irrigants use.

## CONCLUSIONS

QMix™2in1 irrigating solution proved antimicrobial efficacy in short and prolonged duration against *Enterococcus faecalis*. The antimicrobial efficiency of sodium hypochlorite can be improved using full concentration. It was also concluded that different agitation techniques have no effect on the antimicrobial efficacy.

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