Original Article

Comparative Clinical and Microbial Evaluation of Two Endodontic File Systems and Irrigating Solutions in Pediatric Patients

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Abstract

Aims: The purpose of the study was to determine the best combination for chemomechanical preparation in primary teeth using two endo file systems (hand and rotary) along with two different irrigants. **Materials and Methods:** Sixty primary molars indicated for pulpectomy, underwent chemomechanical preparation using endo files (H hand files and rotary Protaper files) and root canal irrigating solutions (Smearclear and QMiX). Samples from root canals were collected before and after the chemomechanical preparation of the canal and were cultured for microbial analysis of *Enterococcus faecalis*. **Results:** Endodontic irrigating solutions showed significant differences of effectiveness on the growth inhibition of bacterial strain. The present study confirmed that the *in vivo* antimicrobial efficacy of QMiX solution was statistically significant when compared to the Smearclear solution. **Conclusion:** Based on the antimicrobial efficacy observed in the present study, it may be concluded that QMiX has a great potential than Smearclear as an intracanal irrigation solution in primary teeth and rotary preparation may be considered as more efficient and time-saving mechanical preparatory technique in primary molars.

Keywords: *Enterococcus faecalis, hand files, irrigating solutions, pulpectomy, rotary files, smear layer*

Introduction

Pediatric endodontics is one of the important clinical procedures used for the treatment of pulp therapies in children. Loss of primary molars, leading to space loss, is an important issue which needs attention in the field of pediatric dentistry. Successful root canal treatment mainly depends on biomechanical preparation with an aim to clean and shape the root canals by removing soft and hard tissue. This, in turn, makes space for irrigants to the apical third and medicaments and subsequent obturating material in the radicular structure. Usually, biomechanical preparation is done with hand files, reamers, burs, and sonic instruments and recently with rotary instruments.[1]

Nickel–titanium rotary instruments are now widely used in adult endodontics as an efficient and effective technique in primary teeth. The effectiveness of endodontic files; rotary instrumentation; irrigating solutions; and chelating agents to clean, shape, and disinfect root canals underpins the success; longevity; and reliability of modern endodontic treatments.[2] The use of chemical agents during instrumentation to completely clean all aspects of the root canal system is central to successful endodontic treatment. Irrigation is complementary to instrumentation in facilitating the removal of pulp tissue and/or microorganisms.[3]

Mechanical instrumentation of the root canals leaves a smear layer covering the dentinal walls[4,5] which contains inorganic and organic materials and may be infected by bacteria and also hinders the penetration of intracanal disinfectants[6] and sealers into dentinal tubules.[7,8] Cleaning and disinfection of the root canal system require the use of inorganic and organic solvent, in addition to an antimicrobial agent. To meet these challenges in the irrigation of the root canal system, new irrigating solutions, QMix™ 2 in 1 (DENTSPLY Tulsa Dental Specialties, Tulsa, OK, USA) and Smearclear (SybronEndo, CA, USA), have been introduced, both to remove smear layer and are bactericidal in single application[9] for species such as

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Enterococcus faecalis, which is commonly recovered from root canal of primary teeth with posttreatment disease.[10]

In consideration of all these facts, the aim of the present study was to compare the cleaning efficacy of rotary Protaper files (DENTSPLY, Switzerland) and H hand files (Mani, Japan) in primary molars using microbial quantification of *E. faecalis* and also to evaluate the efficacy of two irrigation solutions, QMix™ 2 in 1 and Smearclear and also to determine the best combination for chemomechanical preparation in primary teeth.

Materials and Methods

Study design: This was a randomized, clinical trial.

The research protocol was reviewed and approved by the ethical committee of the university before the beginning of this study.

Patient selection: Sample size was calculated after conducting a pilot study. A total number of 60 teeth in 39 children in the age group of 5–10 years who had reported to the department of pedodontics and preventive dentistry were included in the study.

Criteria for case selection:

1. History of spontaneous pain; pain persisted after relieving of aggregating factors and lingered for few minutes
2. Restorable tooth structure
3. Chronic symptomatic pulpalgia with apical periodontitis
4. Pain on percussion, positive
5. Radiographically involvement of pulp with apical periodontitis
6. No evidence of trauma or root fracture.

Using clinical and radiographic examination, pulpectomy indicated cases were included in the study. Before the initiation of this study, informed written consent was obtained from parents or legally responsible persons, permitting the participation of their children. Selected teeth were randomly divided into two groups of 30 teeth each, that is, Group I and Group II using flip of a coin method which was further divided into two subgroups using the same method, Subgroups – IA, IB, IIA, and IIB, according to the type of file system and irrigation solution used [Figure 1].

Under aseptic conditions, the tooth was anesthetized and isolated using rubber dam. Endodontic access was achieved with a sterile high-speed carbide bur using airotor handpiece. On gaining access to the pulp, a sterile broach was inserted into the root canal up to the apical foramina, and the canal content was obtained and transferred into the sterile container containing 5 ml of glucose broth and sealed tightly for transfer of pretreatment sample to the microbiological laboratory [Figure 2]. The samples were collected from the palatal and distal canal of the maxillary and mandibular primary molar teeth, respectively. In Subgroup IA, 15 samples were prepared with rotary protapers under copious irrigation with Smearclear. Copious irrigation with normal saline was done during the chemomechanical preparation.

Following final instrumentation and rinsing with normal saline, the canals were irrigated with 3 ml of distilled water. The canals were then irrigated with 2 ml of Smearclear which was left in the canals for 90 s to remove the smear layer before obturation of the root canal.

In Subgroup IB, same procedure was followed as in Subgroup IA except in the end the canals were irrigated with 2 ml of QMix irrigation solution which was left in the canals for 90 s to remove the smear layer.

In Subgroup IIA, canals were prepared using H hand files in a step-back technique under copious irrigation with saline and sterile water, after which the canals were treated with Smearclear irrigation solution which was left in canals for 90 s. To ensure adequate and even distribution of the solution, the canals were irrigated using a standard irrigation syringe and a 30-gauge needle with an apical–coronal motion to within 1 mm of the working length.

Furthermore, in Subgroup IIB, the samples were prepared with H hand files, but the canals were irrigated with 2 ml of QMiX irrigation solution in the end which was left inside the canals for 90 s.

After cleaning and shaping, the canals were rinsed thoroughly with 3 ml sterile water to remove any excess solution and/or debris. The posttreatment samples were then collected with the help of 20 no. sterile absorbent paper point which was left in the canal for 60 s and transferred to the laboratory for microbial examination [Figure 2].

The root canals were then dried with sterile paper points and subsequently filled by injecting a resorbable calcium and iodoform paste (Metapex-Meta Biomed, USA) followed by the placement of temporary restorative material and patient was recalled for next appointment for permanent coronal restoration after 7 days.

Microbiological examination

About 1.704 g of the UTI Hicrome selective agar media was suspended in 30 ml distilled water, mixed well, and dissolved by boiling for 1 min with frequent agitation until complete dissolution. Then, it was boiled for 1 min until complete dissolution. Sterilize by autoclaving at 15 lbs pressure (121°C) for 15 min. Cool to 50°C. Mixed well and poured into sterile Petri plates.

Standard plate count was done separately for each sample. About 5 ml of bacterial culture was added to 45 ml of sterile diluent.

From this suspension, two serial, 1/100 dilutions were made, and 0.1 ml was plated onto agar plate from the last dilution. The Petri plates were inoculated with Hicrome

UTI selective agar by carefully removing the cover from Petri plate and pouring the agar aseptically into it. The agar and sample were immediately mixed gently moving the plate in a figure-eight motion or a circular motion while it rested on the tabletop. After the pour plates cooled and the agar hardened, they were inverted and incubated at 25°C for 48 h or 37°C for 1–3 days. After incubation, colonies were counted on the plate and colony-forming unit/milliliter (CFU/mL) of the original sample was calculated.

The dilution factor used:

Here, initially, 5 mL in 45 mL was used

Final volume/Sample volume = 50/5 = 10.

Then, two serial dilutions of 1/100.

Total Dilution Factor = $10 \times 100 \times 100 = 10^5$

CFU/mL = cfu/ml

= (number of colonies × dilution factor)/volume of culture plate

= $(n \times 10^5)/0.1$

= $n \times 10^6$ where n is the number of colonies.

Statistical analysis

The data thus obtained were subjected to statistical analysis which was performed using SPSS (Statistical Package for the Social Sciences) version 17.0 for Windows. The colony counts (pretreatment and posttreatment) obtained in all the four subgroups were subjected to one-way anova and Tukey's test.

Results

The pretreatment microbial values in all the four subgroups which were in similar range, but posttreatment counts showed statistically significant differences [Table 1].

The greatest percentage difference was seen in Subgroup IB (47.79), followed by Subgroup IIB (44.45), Subgroup IA (27.38), and Subgroup IIA (20.17). Multiple comparisons in between all the subgroups showed statistically significant differences except in between Subgroup IB and Subgroup IIB [Table 2].

The results of pre- and post-difference in change of values using different types of irrigating solutions and in all the four subgroups statistically significant difference were seen, except when Subgroup IA was compared with Subgroup IIA and for Subgroup IB versus Subgroup IIB. Smearclear irrigation solution, when used with rotary and hand files, showed statistically nonsignificant difference, and also, the efficacy of Qmix irrigation solution was not affected by the type of instrument used (rotary or hand files). Hence, the efficiency of the irrigation solutions was not affected by the type of file system used [Table 3].

The percentage reduction in posttreatment counts in all the four subgroups. The maximum percentage reduction was seen in Subgroup IB, followed by IIB, IA, and IIA (IB>IIB>IA>IIA). The results showed the antimicrobial efficacy of Qmix better than Smearclear [Bar Diagram 1].

Discussion

A practical pulpectomy technique for the primary teeth requires minimum number of appointments with short treatment time. It should result in effective debridement of the root canal without weakening the tooth structure or endangering the underlining permanent teeth and should maintain its function till it exfoliates.[11] Considering that preparation time is an important clinical factor in pediatric patient management, and as these instruments are more convenient to use, their application may be more appropriate in children with behavior management problems.[12]

Table 1: Pre- and post-treatment microbial counts in all the four subgroups

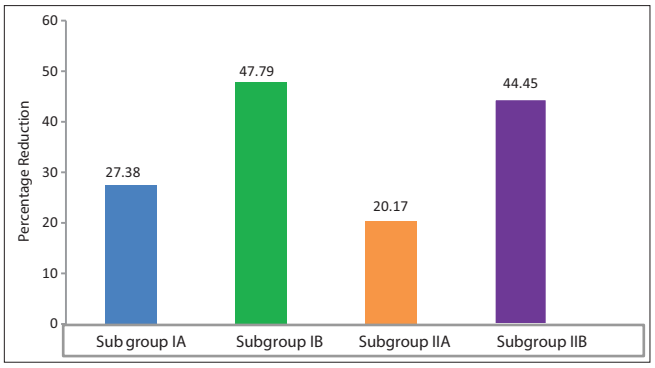
Sample number	Subgroup IA		Subgroup IB		Subgroup IIA		Subgroup IIB	
	Pretreatment	Posttreatment	Pretreatment	Posttreatment	Pretreatment	Posttreatment	Pretreatment	Posttreatment
1	150×10^6	40×10^6	40×10^6	0	137×10^6	60×10^6	20×10^6	3×10^6
2	115×10^6	48×10^6	160×10^6	2×10^6	144×10^6	73×10^6	32×10^6	0
3	126×10^6	25×10^6	156×10^6	3×10^6	145×10^6	62×10^6	56×10^6	12×10^6
4	130×10^6	19×10^6	105×10^6	0	161×10^6	50×10^6	80×10^6	15×10^6
5	74×10^6	0	147×10^6	0	130×10^6	61×10^6	145×10^6	6×10^6
6	67×10^6	15×10^6	180×10^6	16×10^6	136×10^6	53×10^6	176×10^6	7×10^6
7	31×10^6	12×10^6	175×10^6	3×10^6	115×10^6	68×10^6	106×10^6	0
8	48×10^6	16×10^6	146×10^6	4×10^6	68×10^6	42×10^6	189×10^6	4×10^6
9	110×10^6	32×10^6	156×10^6	4×10^6	72×10^6	34×10^6	144×10^6	6×10^6
10	117×10^6	44×10^6	147×10^6	12×10^6	113×10^6	72×10^6	163×10^6	18×10^6
11	130×10^6	70×10^6	112×10^6	7×10^6	121×10^6	44×10^6	124×10^6	4×10^6
12	142×10^6	52×10^6	130×10^6	0	96×10^6	28×10^6	160×10^6	9×10^6
13	129×10^6	46×10^6	156×10^6	0	74×10^6	20×10^6	167×10^6	3×10^6
14	144×10^6	61	130×10^6	2×10^6	59×10^6	26×10^6	145×10^6	4×10^6
15	162×10^6	42×10^6	90×10^6	O	49×10^6	14×10^6	132×10^6	0

All values are in CFU/ml. CFU: Colony-forming units

Table 2: Mean and standard deviation of pretreatment, posttreatment, difference, percentage difference, and percentage change values in all the subgroups

	n	Mean	SD	Minimum	Maximum
Pre					
Subgroup IA	15	111.67	38.88	31.00	162.00
Subgroup IB	15	135.33	36.36	40.00	180.00
Subgroup IIA	15	108.00	35.76	49.00	161.00
Subgroup IIB	15	122.60	52.83	20.00	189.00
Post					
Subgroup IA	15	34.80	19.85	0.00	70.00
Subgroup IB	15	3.53	4.78	0.00	16.00
Subgroup IIA	15	47.13	19.27	14.00	73.00
Subgroup IIB	15	6.07	5.40	0.00	18.00
Difference					
Subgroup IA	15	76.87	28.46	19.00	120.00
Subgroup IB	15	131.80	34.60	40.00	172.00
Subgroup IIA	15	60.87	23.98	26.00	111.00
Subgroup IIB	15	116.53	52.50	17.00	185.00
PerDiff					
Subgroup IA	15	27.38	8.49	15.00	50.00
Subgroup IB	15	47.79	2.79	41.84	50.00
Subgroup IIA	15	20.17	5.77	11.08	28.72
Subgroup IIB	15	44.45	5.78	32.35	50.00
PerChange					
Subgroup IA	15	69.44	13.10	100.00	46.15
Subgroup IB	15	97.66	3.02	100.00	91.11
Subgroup IIA	15	56.58	11.92	72.97	36.28
Subgroup IIB	15	93.73	6.95	100.00	78.57

PerDiff: Percentage difference; PerChange: Percentage change; SD: Standard deviation



Bar Diagram 1: Percentage reduction in all the subgroups

Chemomechanical preparation is one of the most important phases of endodontic therapy. In the present study, rotary Protaper files, H-hand files, QMIX, and Smearclear irrigation solutions were compared. The results indicated significantly better cleaning with Group IB (Protaper and QMix) as compared to other groups [Figures 3-6]. Furthermore, rotary preparation for primary teeth was faster than hand preparation which is in accordance with the studies by Azar and Mokhtare,[13] Ozen and Akgun,[14] and Kuo *et al*.[11]

Only Sx and S2 files were used for canal preparation. S1 and F series files were not used as the increased taper and tip size resulted in excessive apical dentin removal in primary molars and might cause lateral perforation. SX and S2 files were used for canal preparation in rotary file group in this study as the teeth selected for sample collection showed no signs of root resorption.

Elimination of microorganisms with instrumentation alone is reported to be achieved in 28%–47% of cases. Addition of an irrigant such as sodium hypochlorite (NaOCl) or ethylenediaminetetraacetic acid (EDTA) further increases the efficacy against microorganisms. *E. faecalis* is a facultative anaerobic Gram-positive coccus that is present in 24%–74% of asymptomatic and persistent endodontic infections.[15] Some of the reasons contributing to the resilience of *E. faecalis* are its ability to survive long periods of nutritional deprivation, its excellent ability to invade dentinal tubules and its capability to bind to dentin and collagen, and also its ability to maintain pH homeostasis.[16] In an attempt to improve the success rate of endodontic treatment, it is important to target the bacteria responsible for the root canal failures as part of the study design. If irrigants can be proven effective against *E. faecalis*, it is likely they will decrease the persistence of infections after root canal treatment.[17]

Culture obtained before obturation is the best way to determine the long-term prognosis of the tooth. Thus, the difference in canal cleanliness in this study was evaluated by microbiological examination. The volume and method used for irrigation were controlled in all groups. 30G needles with side and apical opening were used as these promoted better apical cleaning at all stages of root canal widening ($P < 0.05$).[18]

The use of chemical agents during instrumentation to completely clean all aspects of the root canal system is central to successful endodontic treatment which helps in the removal of pulp tissue and/or microorganisms. Irrigation dynamics play an important role; the effectiveness of irrigation depends on the working mechanism(s) of the irrigant and the ability to bring the irrigant in contact with the microorganisms and tissue debris in the root canal.[19]

QMiX, an irrigant sold by Dentsply Tulsa Dental, Tulsa, OK, USA, contains 2% CHX and EDTA, in addition to a detergent that completely removes smear layer and is a disinfectant also. It has the benefits of EDTA with a surfactant and CHX while being gentler on dentin. The pH of the solution is considered to be slightly above neutral. The surface-active agent in the solution decreases the surface tension of solutions and thereby increases its wettability.[20,21]

It has been designed to be used as final rinse for 60–90 s in place of 17% EDTA, yet it causes less demineralization of intact dentin collagen than EDTA and substantivity

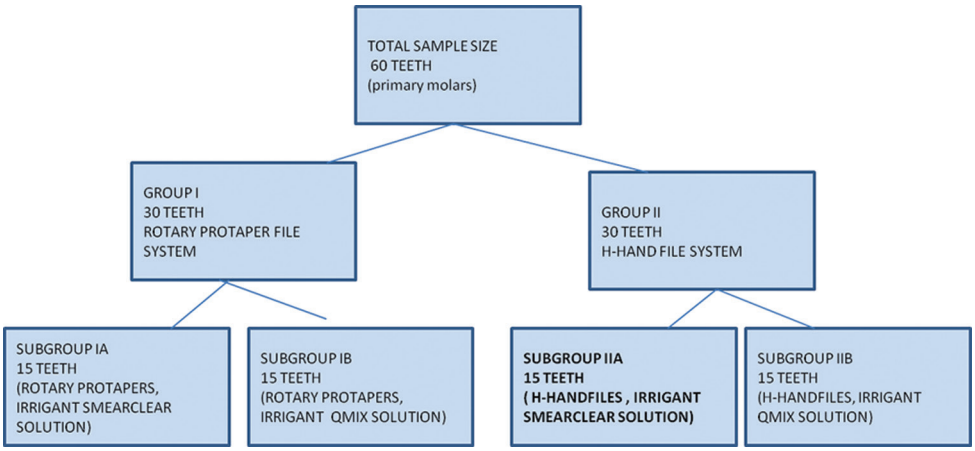


Figure 1: Flowchart showing distribution of subjects

Table 3: One-way ANOVA test of variance applied on preirrigation, postirrigation, difference, percentage difference, and percentage change values in all the subgroups

	n	Mean	SD	*F*	Significant	NS/S
Pre						
Subgroup IA	15	111.67	38.88	1.315	0.279	NS
Subgroup IB	15	135.33	36.36			
Subgroup IIA	15	108.00	35.76			
Subgroup IIB	15	122.60	52.83			
Post						
Subgroup IA	15	34.80	19.85	33.946	0.000	S
Subgroup IB	15	3.53	4.78			
Subgroup IIA	15	47.13	19.27			
Subgroup IIB	15	6.07	5.40			
Difference						
Subgroup IA	15	76.87	28.46	12.373	0.000	S
Subgroup IB	15	131.80	34.60			
Subgroup IIA	15	60.87	23.98			
Subgroup IIB	15	116.53	52.50			
PerDiff						
Subgroup IA	15	27.38	8.49	72.504	0.000	S
Subgroup IB	15	47.79	2.79			
Subgroup IIA	15	20.17	5.77			
Subgroup IIB	15	44.45	5.78			
PerChange						
Subgroup IA	15	69.44	13.10	62.442	0.000	S
Subgroup IB	15	97.66	3.02			
Subgroup IIA	15	56.58	11.92			
Subgroup IIB	15	93.73	6.95			

SD: Standard deviation; NS: Nonsignificant value; S: Statistically significant value; PerDiff: Percentage difference; PerChange: Percentage change. Significant value (P<0.05)

properties of CHX with smear layer removing properties of EDTA. The proprietary design of QMiX is claimed to overcome the past findings of precipitate formations caused by interaction between CHX and EDTA and between NaOCl and CHX, which may be carcinogenic.[9,22] QMIX showed better results in this study.

Smearclear is a 17% EDTA solution containing cetrimide (a quaternary ammonium compound) and an additional proprietary surfactant (polyoxyethylene[10] isooctylcyclohexyl ether). Abou-Rass and Patonai[23] confirmed that the reduction of surface tension of endodontic solutions improved their flow in narrow root canals. Therefore, it may be speculated that the addition of two surfactants to EDTA should improve its penetration ability into narrow apical region of the root canal. The decalcifying effect of chelators in the removal of inorganic component of the smear layer and negotiation of the fine, tortuous, and calcified canal to ascertain patency depends on the root length, application time, diffusion in the dentin, relationship between the amount of available active substance (chelator) and the canal wall surface area, and especially, the solution pH because the demineralization process continues until all chelating agents have formed complexes with calcium.[24] Smearclear has cetrimide in its composition, which is quaternary ammonium compound and a cationic detergent, that is, effective against Gram-negative and Gram-positive microorganisms. In the present study, Smearclear showed less effective results when compared with QMiX.

Irrigants must be in contact with the dentin walls for effective debris removal and penetrate more readily into the root canal system, thus making more surface area available for action. The closeness of this contact is directly related to its surface tension. According to Grossman and Meiman,[25] low surface tension is one of the ideal characteristics of an irrigant.

Under the conditions in which this study was performed QMiX irrigation solution showed better results than Smearclear both with rotary file system and hand file system. Hence, it can be concluded that the efficiency of the irrigation solutions was not affected by the file system used for the endodontic treatment.

Conclusion

The present study confirmed that the *in vivo* antimicrobial

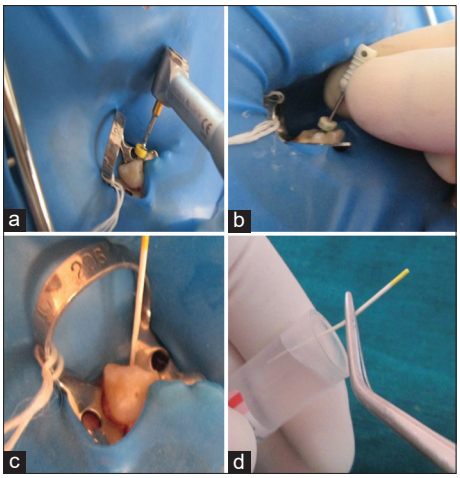


Figure 2: (a) Biomechanical preparation with rotary files. (b) Biomechanical preparation with hand files. (c) Postoperative sample collection with paper point. (d) Sample transferred to glucose broth

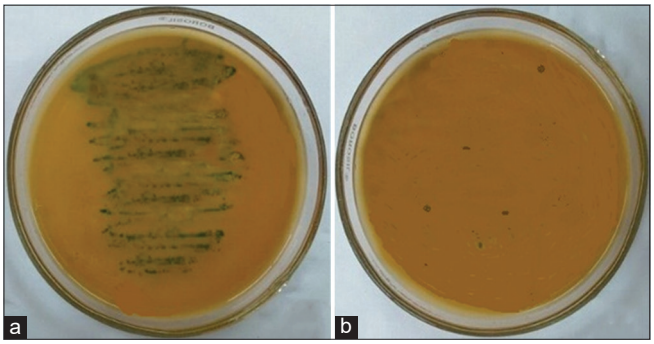


Figure 4: Group IB: Rotary file with QMiX (a) Petri dish showing microbiological colony before cleaning and shaping. (b) Petri dish showing microbiological colony after cleaning and shaping

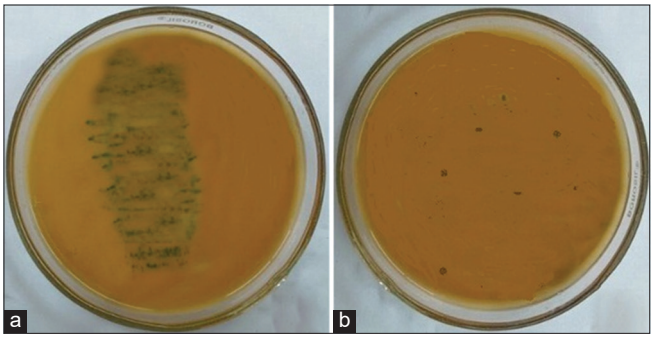


Figure 6: Group IIB: H-file with QMiX. (a) Petri dish showing microbiological colony before cleaning and shaping. (b) Petri dish showing microbiological colony after cleaning and shaping

efficacy of QMiX solution was higher than the Smearclear solution and showed significant differences in effectiveness on the growth inhibition of bacterial strain. It may be concluded that QMiX has a greater potential to be used as an intracanal irrigation solution in primary teeth, and it is also proposed that the rotary preparation is the more efficient and time-saving mechanical preparatory technique (rotary vs. hand files) in primary molars. Further, clinical and *in vitro* trials are needed to verify the efficacy

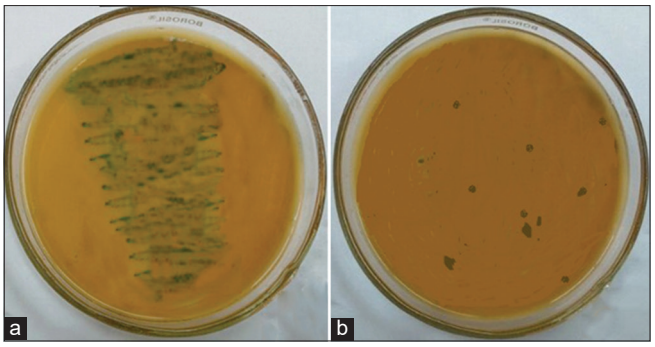


Figure 3: Group IA: Rotary file with smear clear. (a) Petri dish showing microbiological colony before cleaning and shaping. (b) Petri dish showing microbiological colony after cleaning and shaping

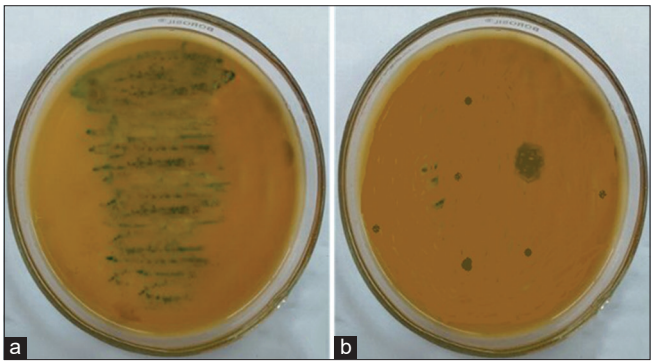


Figure 5: Group IIA: H-file with Smearclear (a) Petri dish showing microbiological colony before cleaning and shaping. (b) Petri dish showing microbiological colony after cleaning and shaping

of the new QMiX irrigating solutions in aiding debridement and cleansing/disinfecting the endodontic space in primary teeth.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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