

Effect of Different Irrigating Solutions on the Apical Sealing Ability of Resin Based Root Canal Sealer

Syed Saqib Raza¹, Syed Yawar Ali Abidi², Affan Ahmed³, Naheed Najmi⁴, Muhammad Atif Saleem Agwan⁵, Anosha Saqib⁶

Abstract

Objective: To assess the effect of different irrigating solutions (Normal saline, 5.25% NaOCl and 90% Ethanol) on apical sealing ability of resin based root canal sealer filled with single cone obturation technique in extracted teeth.

Methods: From March 2022 to September 2022, the case control research was carried out at the Department of Operative Dentistry, Karachi Medical and Dental College in Karachi. Sample size of 30 single root teeth were decoronated and roots were divided into Group A and B. Group B is subdivided into two cases according to the type of irrigating solution used. Group A irrigation solutions include 5ml of Normal saline solution, while group B include 5ml of 5.25% Sodium Hypochlorite and 5ml of 90% Ethanol solution. Teeth were prepared, obturated, placed in 2% methylene blue dye and extent of dye penetration was done under a digital stereomicroscope and maximum leakage was measured by using software. Data was analyzed on SPSS version 26.0.

Results: All solutions were normally distributed. While comparing both groups, Ethanol has the lowest mean value of dye penetration i.e. 1.07 ± 0.63 which means that this irrigating solution has least micro leakage and provides effective seal of resin sealer to the root canal wall filled by using single cone obturating technique. Case group irrigation solutions has significant p-value i.e. 0.000 which indicates absolute absence of micro leakage. Upon Comparison of mean value of Sodium Hypochlorite and Ethanol, Ethanol is more efficient irrigation solution as it has shown lesser dye penetration as compared to Sodium Hypochlorite.

Conclusion: It has been concluded that among all the solutions, Ethanol has proved to be the most effective irrigation solution followed by Sodium Hypochlorite, showed least dye penetration and hence least micro leakage.

Keywords: Endodontic, Sealers, Epoxy Resin, Root Canal Treatment, EDTA

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Introduction

The preservation of a healthy dentition is crucial for general health. In addition, patients increasing desire to keep their teeth will result in a greater demand for complex dental care, with root canal therapy being seen as a crucial component of these treatments¹.

¹ Department of Operative Dentistry, Karachi Medical and Dental College

² Operative Dentistry, Jinnah Sindh Medical University

³ Dental Materials, Karachi Medical and Dental College

⁴ Operative Dentistry, Liaquat College of Medicine and Dentistry

⁵ Department of Restorative Dentistry, College of Dentistry, Qassim University, Saudi Arabia

⁶ General Dentist

Correspondence: Dr. Saqib Raza
Department of Operative Dentistry,
Karachi Medical and Dental College
Email: drsaqibnaqvi8489@gmail.com
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Root canal therapy is a treatment performed for the infected pulp of teeth to eliminate infection² and for protection of the involved teeth from further destruction by bacterial invasion while maintaining the function of teeth in the oral environment. Lubrication is required at every stage of root canal treatment, from dental dam placement to canal obturation.

The assessment, therapeutic plan, disinfectant quality, instrument quality, and filling techniques are all important factors in the success of endodontic treatment³. The purpose of root canal treatment is to achieve adequate seal of the periapical area⁴.

Adequate debridement, cleaning as well as shaping of the root canal with complete filling, sealing of tooth apex is important in order to reduce the colonization of microorganism and to achieve functional and aesthetic rehabilitation⁵.

The outcome of endodontic treatment is dependent on the selection of irrigating solution and type of sealer used⁶. Many of the root canal sealers are available based on these properties like bio ceramic, calcium hydroxide based sealers, zinc oxide based and resin based. An ideal root canal sealer should have good adhesion to dentine, bio-compatible, dimensionally stable, non-toxic, radiopaque, and have optimum bond strength⁷.

The third and final part of the endodontic triad is the root canal system's complete and fluid-tight three-dimensional closure. Gutta-percha is the oldest and closest substance that has met this requirement (GP). Several substances have been investigated and evaluated as endodontic filling materials, but GP has been the most frequently utilized and has become the industry standard for many years. Additionally, it has successfully used a variety of obturation procedures while adhering to its fundamental requirements⁸.

Modifications in instrument design and materials have been made to avoid procedural errors and cleaning of canal⁹. The success rate of the technique is largely based on the apical seal, which is created and maintained during root canal irrigation. Irrigation is made up of a variety of components and that efficient irrigant delivery and agitation accomplish mechanical, chemical, and microbiological activities, all of which are necessary to maintain a clean canal system¹⁰.

Root canal sealers have been helped by the use of many irrigation materials. Their distinct properties make them preferable to use by the dentists. They include 5.25% NaOCl, Normal saline, 2 % Chlorhexidine Ethanol and etc. They are strongly oxidizing and having a broad-spectrum antibacterial impact. Sodium hypochlorite (NaOCl) has been used to disinfect clothes, equipment, surfaces, and drinking water. NaOCl is a widely available

and affordable chemical. The most often used irrigating solution in endodontic is sodium hypochlorite (NaOCl). It has a special ability to disintegrate organic and necrotic smear layer components¹¹.

Due to its broad-spectrum antibacterial activity and significantly lower toxicity than NaOCl, Chlorhexidine (CHX) is a substitute irrigant for NaOCl. CHX works equally well when applied as a gel or a solution.

The 70% ethanol irrigation demonstrated a significantly higher proportion of clean root canal walls and a deeper depth of clean dentinal tubules when compared to 2.5% sodium hypochlorite and 17% EDTA-T irrigation¹². Using 95% ethanol to dry the root canal system can improve obturation in baby teeth¹³.

By increasing the durability of the resin-dentin bond and the integrity of the hybrid layer after irrigation using the most effective irrigation solution, which has no/littlest microleakage displayed on stereomicroscope, this would assist us to enhance the prognosis of root canal treatments and reduce the likelihood of their failure.

Due to scant availability of data, there is a need to conduct study on the topic so that more durable seal can be obtained which facilitates long term root canal success. Therefore, this study was planned with the objective to assess the effect of different irrigating solutions (5.25% NaOCl, Normal saline and modified 90% Ethanol) on apical sealing ability of resin based root canal sealer filled with single cone obturating technique in extracted teeth.

Materials and Methods

Two research locations were used to conduct the study. Department of Operative Dentistry, Karachi Medical and Dental College was selected as the study location. The second study location was Department of Material Engineering, NED University Karachi. The use of two study locations has increased the study's generalizability and external validity. The sample size was calculated by using OpenEpi calculator. The Two-sided Confidence level (1-alpha) was 95%, power (% chance of detecting)

was 80, ratio of controls to cases was 0.8, Hypothetical proportion of controls with expo was sure 10, hypothetical proportion of cases with exposure 40, least extreme Odds Ratio to be detected 6.0 Kelsey et al. The sample size of cases was 20 while sample size of Controls was 10, therefore the total sample size was 30.

The inclusion criteria was single rooted teeth, teeth with a single canal, teeth with mature apices, teeth with 12-15 mm long roots so as to eliminate root length as a variable. The exclusion criteria was teeth with calcified canals, teeth with curved canals, external or internal resorption, previous restorations on the teeth.

In this case control study, the cases and controls were selected after meeting the inclusion and exclusion criteria using a non-probability convenience sample technique.

The ethical review committee provided their approval (ref # 20/21). A total of 30 single-rooted teeth were decorated, and the roots were separated into Group A, which is control groups and Group B, which contains two sub-experimental groups—each with n=10 depending on the irrigating solution utilized. (Table 1.)

Table 1. Showing group and subgroup divisions of controls and cases.

Group	Name of Irrigating Solution
Group A (Control)	5ml of Normal saline
Group B (Cases)	5ml of 5% Sodium Hypochlorite- 5ml of 90% Ethanol

Permanent, single-rooted human teeth were obtained from the Oral Surgery and Orthodontic Department, kept, and cleaned before being used to prepare the samples. Until they were utilized, teeth were stored in distilled water. As the root length would be 15mm, the teeth's crowns were removed using a diamond disc while being cooled by water. The canal was prepared by a K-type file of size 15. (Mani Inc., Tochigi, Japan). The root apex was chosen as the working length, and it was set at 1mm. The root canals were prepared utilizing the crown-down procedure to F2 and a rotary NiTi file system (Protaper Universal, Dentsply, Switzerland).

Between files, root canals were irrigated with 5 ml of the following irrigating solutions: Normal saline (Group A), 5.25% NaOCI modified 90% Ethanol (Group B).

Finally, all samples were irrigated with 5 ml distilled water. The irrigation was performed using a 27-gauge Max-i-Probe needle (DentsplyMaillefer, Ballaigues, Switzerland), which were inserted as deep as possible into the canal without binding.

The samples were obturated using absorbent paper points to dry the canals, followed by the F2 single cone guttapercha coated in AH Plus sealer to complete the obturation to its full working length (Dentsply Co). A radiographic evaluation of the obturation's quality was conducted. Glass Ionomer Cement was used to close the access cavity (3M ESPE Ketac Molar). The apical 2 mm of the teeth were not coated with nail polish twice. The samples will be incubated for a week at 37°C and 100% humidity to allow the sealers to fully set.

Because of its dependability and utilization by (Verissimo DM and do Vale MS, 2006), the methylene blue dye penetration method was employed to assess the apical microleakage. Samples were dipped in 2% methylene blue dye and kept at 37°C for 72 hours before being completely rinsed under running water and having the varnish removed using polishing discs (Mani, Japan). Each root's 7 mm apex was cut off longitudinally in a buccolingual orientation, and the mesial or distal surface was then cut horizontally with a flexible diamond disc while being cooled by water. To improve the examination of dye penetration, the filling material was subsequently removed from the 7 mm proximal parts of each sample using an endodontic explorer. A 20 X digital stereomicroscope (Motic Product # DMW-143) was used to assess the depth of dye penetration.

Pictures were captured, saved, and the maximum leakage was measured by using software of the manufacturer company of the stereomicroscope. (Fig 1.)

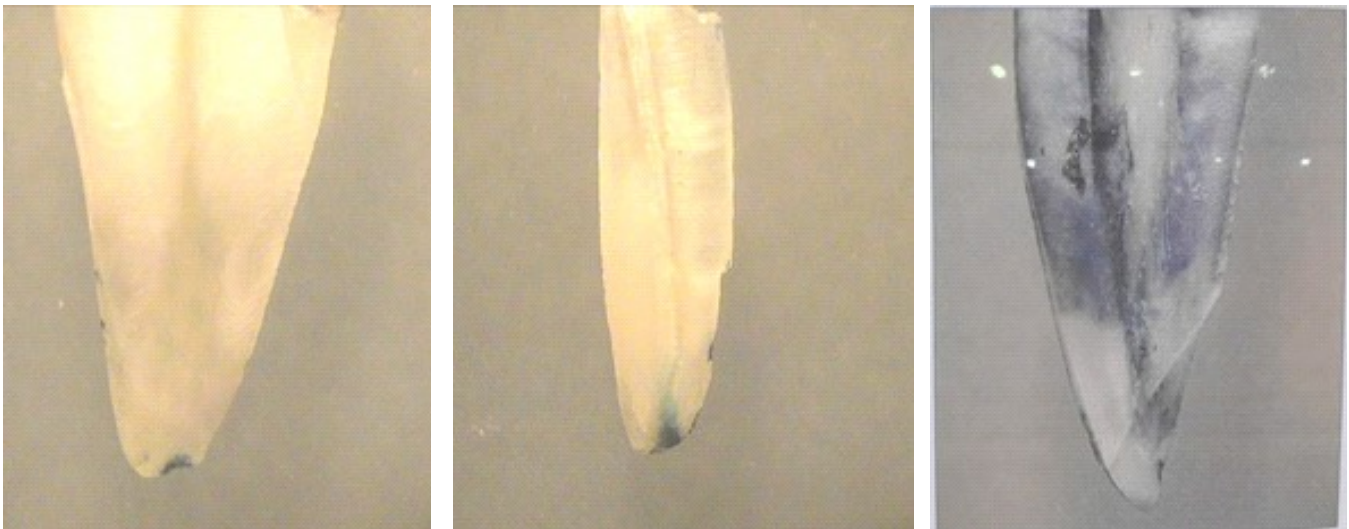


Fig 1. Assessment of Dye penetrations (from right to left) Ethanol, Sodium hypochlorite & Normal

Data was analyzed using SPSS version 23. Descriptive statistics were performed. The mean and standard deviations of the depth of dye penetration were determined. Inferential statistics were performed. The ANOVA test was used and a post-hoc Tukey test for further analysis. The p value of ($p \leq 0.05$) was considered significant.

Results

The normality graph was plotted for each solution and it shows that all the solutions are normally distributed as the p-value of all solutions including cases and controls is greater than 0.05. The value for Normal Saline was 0.138, Hypochlorite, 0.204, Ethanol was 0.96.

To examine the variation between the control group and the case group, ANOVA test was used and it was significant ($p=0.000$). The results of this study revealed that p value was significant for all irrigating solutions.

So in the Table 2, all the groups' mean was found significantly different ($p < 0.05$). It means that dye has been penetrated in all samples which depicts that micro leakage is present among all irrigating solutions and none of the solution provide absolute seal. The significant p values of t-test shows almost all groups are significant and it is confirmed.

Table 2. Comparison between the Mean Depths of Dye Penetration Caused By Irrigating Solutions

Solutions	Mean \pm SD	P-value
Saline	4.33 \pm 1.64	
Hypo	2.00 \pm 1.04	0.000
Ethanol	1.07 \pm 0.63	

P-value < 0.05 considered as significant.

Comparison between the depth of dye penetration caused by different irrigating solutions was done by performing ANOVA test for both groups, Ethanol has the lowest mean 1.07 ± 0.63 which means that this irrigating solution has least micro leakage and provide effective seal of resin based sealer with the wall of canal filled by single cone obturating technique in extracted teeth. The results shows significant p-value i.e. 0.000 which indicates presence of micro leakage in control group irrigation solutions. (Table 3.)

Each of the control and case groups, as well as each of their subgroups, showed varying degrees of apical dye leakage. Although on comparing the mean value of both efficient solutions of cases and controls i.e. Sodium Hypochlorite and Ethanol it has been observed that the Ethanol is more efficient irrigation solution as it has shown least dye penetration as compare to sodium hypochlorite. (Figure 1.)

Table 3. Comparison between the depth of dye penetration caused by the irrigating solutions

Irrigation solutions	Mean difference	p-value	95% Confidence Interval of the Difference	
			Lower	Upper
Normal Saline	4.33000	.000	3.1511	5.5089
Sodium Hypochlorite	2.00000	.000	1.2558	2.7442
Ethanol	1.07000	.000	.6163	1.5237

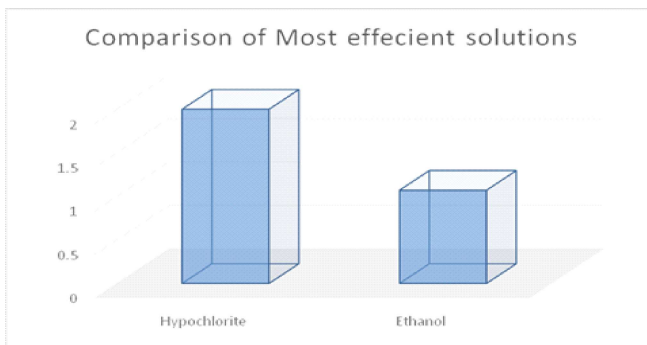


Fig 2. Showing comparison of both efficient solutions.

Discussion

The development and maintenance of a three-dimensional sealing of the root canal system is essential for a successful root canal operation. Toward acquire this various obturation methods and materials were introduced as well as assessed for the hermetic apical seal¹⁴. Since irrigations are crucial for properly cleaning the root canals; the use of certain solutions in combination with mechanical equipment has been practiced for a long time. The capacity of many irrigants to enter into the tubules can be increased, increasing the ultimate result against resistant pathogens like *Enterococcus faecalis*, which is a major factor accounts for failure of root canal therapy. The ideal irrigant solution for extrusion into the periodontium should be micro biocidal, break down organic tissues, and provide mechanical cleaning without damaging the periradicular tissues¹⁵.

The creation of novel obturation system types may provide a solution to the problem of micro leakage associated with materials already in use. Root canal irrigation fluids may change the radic-

ular dentin’s chemical and structural makeup. Hence altering its solubility and permeability properties, which in turn has an impact on how well things, adhere to dentin surfaces¹⁶. In order to evaluate the effects of various irrigating solutions (5.25% NaOCl, Normal saline and modified 90% Ethanol) on the ability of resin-based sealers to adhere to the root canal walls filled with single cone obturating techniques in extracted teeth, this study was carried out.

Current study added variables that closely resembled clinical settings by using extracted human teeth. The rotary NiTi file system (Protaper Universal, Dentsply, Switzerland) using the crown-down technique to F2 was used to instrument extracted single rooted teeth with almost identical apical diameters and root lengths. Since rotary instrumentation was found to be more swift, cosy, and efficient than hand instrumentation.

As a result, factors that may affect apical leakage were minimized, including anatomical variance, canal size, and apical foramen diameter using same instrument and technique to prepare and obturate root canal.

Many methods have been used to assess the capacity of root canal filling materials to seal the apex. The methylene blue dye penetration method was selected for the current experiment because it is a low-cost, dependable, user-friendly, and effective staining technique. The dye leakage method is sufficiently valid, according to various publications, if the experimental conditions, such as the sample type, dye type, and length of dye immersion, have been standardised¹⁷.

The current study used methylene blue dye penetration to evaluate the apical micro leakage since it is an affordable, dependable, and easy-to-use technique¹⁸.

It also exhibits a high degree of staining ability and a molecular weight that is lower than that of bacterial toxins. The material used to plug root canals can limit the leakage of larger molecules, such bacteria and their byproducts, while still enabling small molecules, like colours, to get through¹⁹. A 72-hour immersion period was employed

in the current investigation because the experimental methods did not include a vacuum or other active penetration equipment.

In this study, the normality test was assessed using Shapiro-Wilk Test and it shows that all the solutions are normally distributed as the p-value of all solutions including cases and controls is greater than 0.05.

The study's findings showed that all irrigating solutions had significant p-values. So it means that dye has been penetrated in all samples which depict that micro leakage is present among all irrigating solutions and none of the solutions provide the absolute seal.

To thoroughly clean the root canals, lubricate the dentinal wall, flush out waste, dissolve organic and inorganic material, and making resin-based sealants more adherent.

In this study, Sodium Hypochlorite, Chlorhexidine, and Normal Saline were utilized to compare the depth of dye penetration produced by irrigating solutions for controls.

Normal Saline is a common irrigant used in many irrigation procedures as well as root canal treatment. Because of its isotonicity with the body's pH, it provides effective debridement of debris from the root canal without causing any noticeable side effects²⁰.

Because of its strong antibacterial capabilities, ability to break down organic molecules, and clearance of necrotic tissues, sodium hypochlorite has become a widely utilized irrigant. Although Nabavizadeh M. and co-workers reported NaOCl's drawbacks to include an unpleasant taste and odor, toxicity, the possibility of mandibular nerve paresthesia, allergies, the breakdown of collagen, the breakdown of dentin, and a rise in coronal microleakage of adhesive restorations²¹.

Several endodontic irrigating solutions, including as Sodium Hypochlorite (NaOCl), Chlorhexidine gluconate (CHX), Hydrogen Peroxide (H₂O₂), and Ethylene Diamine Tetraacetic Acid (EDTA), have been recommended during root canal instrumentation to promote cleaning and disinfection of the

root canal system.

Using 70% ethanol revealed significantly more root canal walls that were clean and cleaner dentinal tubules that were deeper. ($p=0.05$)²². The properties of dentin (roughness and surface free energy) are improved by Ethanol solutions (70 and 100 percent), which improves the wet ability of AH Plus sealer on dentin surfaces²³.

In the cases group, the mean depth of dye penetration of irrigation solutions, Ethanol has the lowest mean value of dye penetration i.e. 1.07 ± 0.63 which means that this irrigating solution has least microleakage and provide effective seal of resin based sealer to the root canal wall filled with single cone obturating technique in extracted teeth.

The results shows significant p-value i.e. 0.000 which indicates absolute absence of microleakage with case group irrigation solutions. Each of the control and case groups, as well as each of their subgroups, showed varying degrees of dye escape.

In Table 3 and 4, as shown, the mean values and standard deviations of the apical dye leakage in control and cases group are displayed. Although on comparing the mean value of both efficient solutions of cases and controls, it has been observed that the Ethanol is more efficient irrigation solution as it has shown least dye penetration followed by Sodium Hypochlorite. Small sample size and in vitro study were the study limitations.

It is recommended that additional longitudinal studies be designed to look into the role of irrigants. Large sample sizes need to be examined. In vivo studies must be planned and conducted. Planning a multi-center study at national level is advisable which will represent the whole population of Pakistan. A public awareness campaign should be designed to inform people about oral hygiene instructions and early diagnosis of dental caries so that root canal treatment is prevented.

Conclusion

It has been concluded that the dye penetration is present among all irrigation solutions. Among all, Ethanol has proved to be the most effective irrigation solution followed by Sodium Hypochlorite as they showed least dye penetration and hence least micro leakage.

Conflict of Interest

Authors have no conflict of interest and no grant or funding from any organization

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