ORIGINAL RESEARCH

Assessment of Penetration of Low Surface Tension Vehicles in Dentinal Tubules using Stereomicroscopy

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Abstract

Aim: To evaluate and compare the dentinal tubule penetration of glycerine, propylene glycol and ringer's lactate solution.

Materials and methods: Forty-five single-rooted human mandibular premolars with mature apices were decoronated keeping a length of 12 mm of a root. Biomechanical preparation till rotary protaper F2 and irrigation according to the protocol of all the roots was performed. The specimens were randomly assigned into three random groups (n = 15) of glycerine, propylene glycol and ringer lactate mixed with safranin o dye. Roots were split into two halves using disks. The evaluation of the area of penetration of glycerine, propylene glycol, and ringer lactate solution was performed using stereomicroscope and Image J software. For analysis single way ANOVA test followed by post hoc test was used. The level of significance was set at $p < 0.05$.

Results: The maximum depth of dye penetration with propylene glycol was significantly greater than glycerine and ringer lactate solution when the level of significance was set at $p < 0.05$

Conclusion: Propylene glycol penetration in the dentinal tubules was more effective than glycerine and ringer lactate solution indicating its potential use in delivering intracanal medicaments

Clinical significance: The low surface tension vehicles help in propagating the intracanal medicaments into the canal irregularities to aid in thorough disinfection of the canals.

Keywords: Glycerine, *In vitro* study, Propylene glycol, Ringer lactate, Stereomicroscope,

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Introduction

Endodontic therapy aims in the reduction or elimination of pathological microorganisms from the root canal system to achieve clinical success.[1] The viable bacteria reside deep within the dentine, cementum and periapical tissues.[2] Complete elimination of such bacteria even after thorough biomechanical preparation may be difficult to accomplish. Hence, the use of intra-canal medicaments is proposed. These medications act as a physiochemical barrier which prevents root canal reinfection and bacterial proliferation between appointments.[3] The capability of penetration of the solution in the main and lateral canals into the dentinal tubules is governed by wettability. The wettability of any solution in dentin is related to its viscosity and surface tension. Studies have shown increased tubular penetration with decreased viscosity and surface tension.[4,5]

The vehicles are suitable mediums to deliver the drug mixture into infected root canals. There are various low surface carriers like glycerine, propylene glycol, camphorated parachlorophenol, distilled water, saline, anesthetic solutions, etc. The ability of the vehicle to facilitate better diffusion of the medicament through root dentine, cementum, anatomical aberrations like fins, isthmus and periradicular tissues must be taken under consideration while choosing an appropriate vehicle.[6] Chemically, available vehicles can be classified into three categories (Table 1).[7]

The viscous vehicles followed by hydrosoluble vehicles are preferred to use along with intracanal medicaments. Oily vehicles are non-water-soluble substances that promote the lowest solubility and diffusion of the paste within the tissues.[8]

The purpose of this study was to determine the efficiency of glycerine, propylene glycol and Ringer lactate solution to diffuse into dentine and through the root canal system using a dye diffusion protocol.

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Aim

To evaluate and compare the dentinal tubule penetration of glycerine, propylene glycol, and Ringer's solution.

Objectives

- To evaluate the dentinal tubule penetration of glycerine
- To evaluate the dentinal tubule penetration of propylene glycol
- To evaluate the dentinal tubule penetration of ringer lactate Solution
- To compare the dentinal tubule penetration of glycerine, propylene glycol and Ringer's solution.

Methodology

For this study, 45 single-rooted human mandibular premolars with mature apices which were extracted for orthodontic purposes were selected. The teeth were freshly extracted and noncarious.

Table 1: Types of vehicles

Hydrosoluble vehicles	*Viscous vehicles*	*Oily vehicles*
• The rate of ionic dissociation is high • Solubility rate high. Hence, rapidly resorbed by macrophages • Less effective as a low intracanal time of the medicament than viscous vehicles	• High molecular weight leading to slow rate of dispersion • Lower solubility than hydrosoluble vehicles • More effective as for more time the medicament is in the canal	• Lowest diffusion of the paste within the tissues • Lowest solubility • Least effective amongst all vehicles
• Distilled water • Saline solution • Ringer's solution • Local anesthetics with or without a vasoconstrictor • Anionic detergent solution	• Polyethylene glycol • Glycerine • Propylene glycol	• Camphorated parachlorophenol • Metacresylacetate • Olive oil

The exclusion criteria for the sample selection was teeth with open apices, root caries, Severe attrition, teeth with a history of root canal treatment or restoration, evidence of external resorption, hypercementosis or cracks (Fig. 1). The teeth were stored in sterile saline solution until the experiment was performed. For the preparation of specimen, the teeth were decoronated keeping a length of 12 mm of a root. Canal patency was established using 10# K file, and working length was determined. Biomechanical preparation of all the roots was performed up to rotary F2 Protaper using endo-motor. The root canals were irrigated by 5 mL 17% EDTA and 10 mL of 2.5% sodium hypochlorite and the final rinse with 5 mL Distilled water. The specimens were randomly assigned to 3 random groups (n = 15): Group 1: Glycerine, Group 2: Propylene glycol, Group 3: Ringer lactate solution. The dye safranin O was mixed with glycerine, propylene glycol and Ringer's solution to make 1% solution. Two milliliters solution was introduced in each root canal (Fig. 2). The orifices were sealed with inlay wax. All samples were maintained at 37 °C. After 24 hours, roots will be split into two halves using disks. For evaluation of the area of penetration of glycerine, propylene glycol, and Ringer lactate pictures were captured using stereomicroscopy (ZEISS- Stemi DV4) at 12 × magnification. (Fig. 3) The images were subsequently treated to delineate the split surfaces of the root from the root canal wall and its background. ImageJ software was used for Image analysis to determine the area of dye penetration (Fig. 4).

Statistical Analysis

- For analysis single way ANOVA test followed by post hoc test was used
- The level of significance was set at <0.05

Results

The results showed that propylene glycol with maximum penetration depth (7.53 ± 0.65), followed by glycerine (3.04 ± 0.39) and least with Ringer lactate (1.38 ± 0.44) and the difference was found significant (Graph 1).

Post hoc analysis showed that statistically significant result was obtained when propylene glycol was compared with glycerine group (p <0.05) and Ringer lactate group (p <0.05) (Table 2).

Discussion

Amongst the various available vehicles used for intracanal medicaments—glycerine, propylene glycol, and Ringer lactate had been chosen due to the ease of availability and cost-effectiveness.

According to the results, the maximum area of dye penetration was seen in propylene glycol group. In 1957, first reported the use of propylene glycol as a vehicle was by Saiijo.[5] In 1995, Simon et al. suggested propylene glycol be the best vehicle along with calcium hydroxide intracanal medicaments.[7]Cruz et al. in 2002 stated that propylene glycol delivered dye through the root canal system rapidly and more effectively than distilled water.

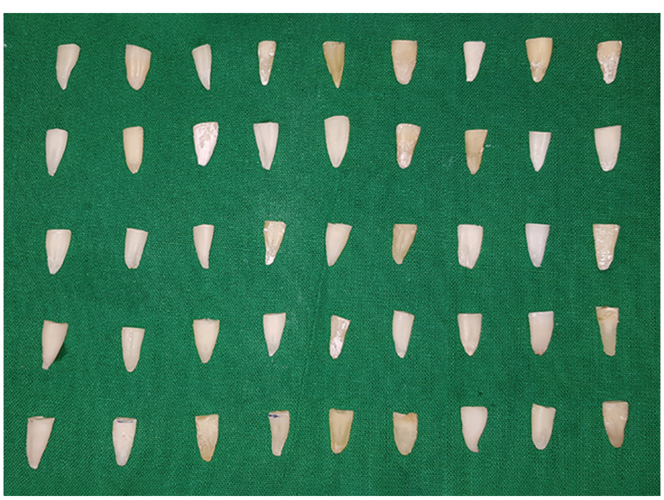
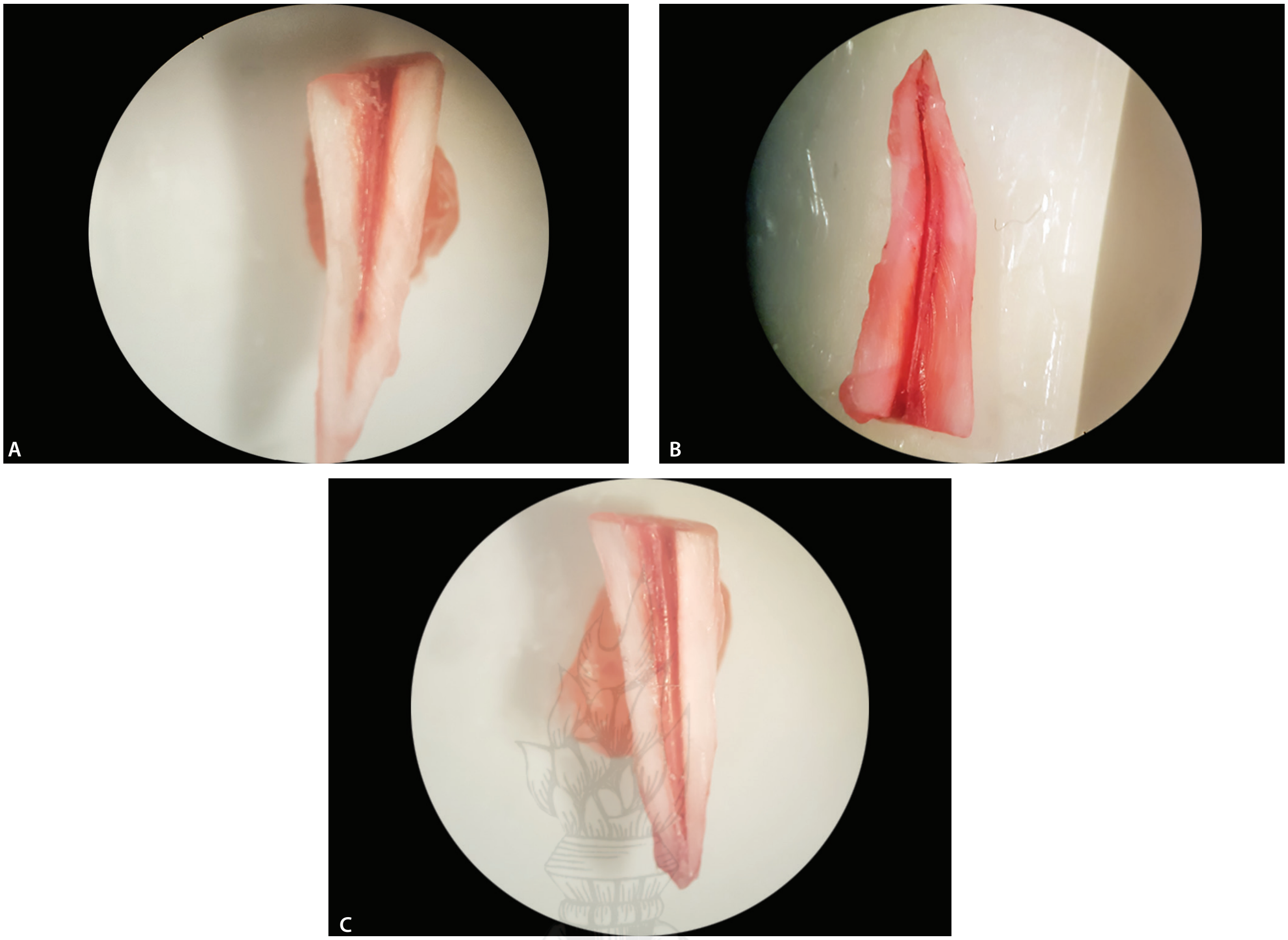


Fig. 1: 1–45 samples

Fig. 2: Injection of the vehicle and dye into the specimen



Figs 3A to C: (A) SEM image of glycerin; (B) SEM image of propylene glycol; (C) SEM image of Ringer lactate

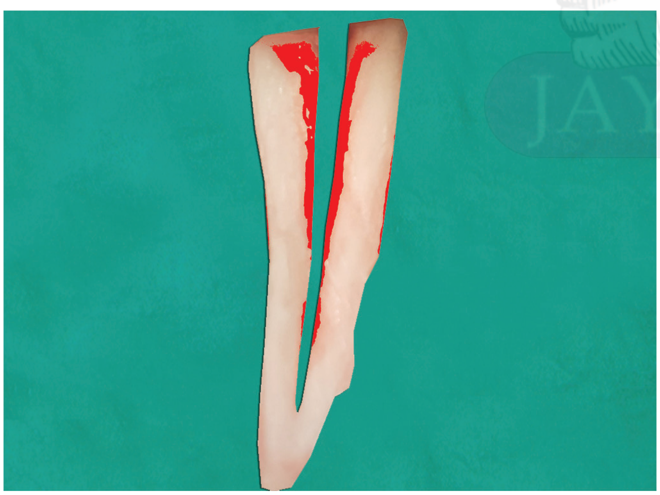
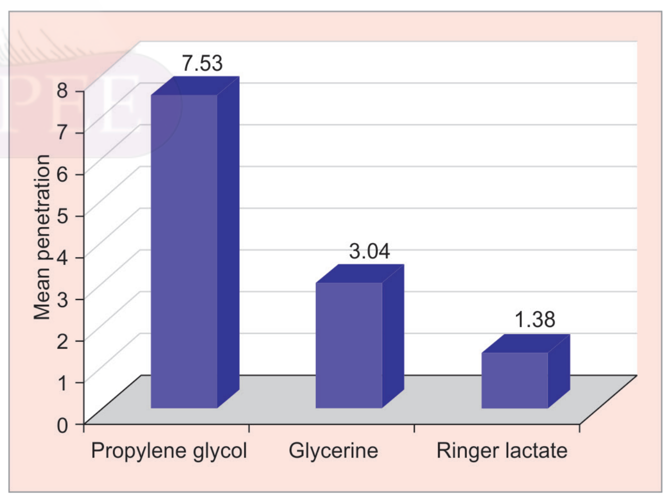


Fig. 4: Image J analytic image



Graph 1: Mean scores of penetration of dentinal tubules of three groups

1,2-propanediol, the configuration of propylene glycol and the hygroscopic nature allows the better penetration and sustained release of the medicament for a prolonged time. In 1965, according to Olitzky et al. propylene glycol showed marked germicidal efficiency which can be useful in preventing and treating microbial infections.[6] Nalwade et al. in 2015, concluded that propylene glycol possessed antibacterial efficacy against *E. coli*, *S. mutans* and *E. faecalis* at 50%, 25%, and 50 % concentrations while polyethylene glycol was not effective against *E. faecalis*. Glycerine exhibited activity only at 100% concentration in this study. Hence, propylene glycol has an additional advantage over glycerine to be chosen as the vehicle of choice.[9]

Table 2: Comparison of mean scores of penetration of dentinal tubules amongst three groups by one-way ANOVA

			95% confidence interval for mean			
	Mean	*Std. deviation*	*Lower bound*	*Upper bound*	*F*	*Sig.*
Propylene glycol	7.53					
	0.65					
	0.39	7.89	600.032	0.001		
Glycerine	3.04	0.39	0.44	3.26		
Ringer lactate	1.38	0.44	1.14	1.62		

Post hoc test		
Group	*Group*	*p value*
Propylene glycol	Glycerine	0.001
	Ringer lactate	0.001
Glycerine	Ringer lactate	0.001

In 1811, glycerine was coined by Chevreul. It is a sweet tasting colorless liquid. In, 1968 Steiner et al. first reported the use of glycerine as a vehicle with calcium hydroxide.[10] Glycerine was preferred due to the nonirritant, nontoxic and lubricant nature. When compared with water, calcium hydroxide when mixed with glycerine showed more density of the paste in the apical one third of the root in a study by Rivera et al.[11] Calcium hydroxide dissolves slightly in water but more readily in glycerine by breaking down of the large crystals to individual molecules of $Ca(OH)_2$.[12] And hence, in a study in 1998 by Alacam et al, glycerine help penetrate the calcium hydroxide more than the distilled water. Calcium hydroxide dissolves more readily in glycerine than distilled water by breaking down the large crystals to individual molecules of calcium hydroxide.

In 2012, Mallya et al. concluded that aqueous vehicles produced lower contact angles (distilled water < chlorhexidine < anesthetic solution) compared to non-aqueous vehicles (glycerine < propylene glycol <iodoform).[13]

The constituents of the Ringer lactate solution are sodium chloride (8.6 g) calcium chloride (0.33 g) potassium chloride (0.3 g) and water (1 L). Since 1959, it has been used for treatment of traumatic injuries.[14] The use along with intracanal medicament has also been reported. It is a type of hydrosoluble vehicle. In 2002, Ozcelik et al. compared glycerine, saline, anesthetic solution, and ringer lactate solution as vehicles to be used with calcium hydroxide. Saline and ringer lactate showed higher surface tension values followed by glycerine and anesthetic solution, with the conclusion that Ringer lactate was the least desirable vehicle.[15]

In 1977, Lester and Boyde described the smear layer as 'organic matter trapped within translocated inorganic dentine.[16] It may harbor bacteria and also limit the effective penetration of intracanal medicaments and irrigant. Hence, the removal of smear layer is necessary for which sodium hypochlorite and EDTA have been used in this study, the alternate use of sodium hypochlorite and EDTA can dissolve organic tissues and to demineralize the smear layer. Hence, Goldman et al. stated that the effective final rinse was 10 mL of 17% EDTA followed by 10 mL of 5.25% sodium hypochlorite. [17]

Safranin O is an aniline, type biological stain, also known as basic red 2. It has been used in various studies for identifying the presence and location of caries, penetration of Intracanal medicaments in dentinal tubules. The reason is said to be the solubility in the solvents.

The analysis of the sections of the specimen was done using image J software which is an open source Java image processing program inspired by NIH Image. This software has been widely used in various fields of dentistry to measure roentgenological attachment, bone density or measurement of microleakage or dye penetration. ImageJ enables an efficient and bias-free visualization and measurement of the total surface area penetrated by the dye. [18]

Conclusion

Propylene glycol penetration in the dentinal tubules was more effective than glycerine and Ringer lactate solution indicating its potential use in delivering intracanal medicaments.

Clinical significance

The low surface tension vehicles help in propagating the intra-canal medicaments into the canal irregularities to aid in thorough disinfection of the canals.

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