Effect of a Low Surface Tension Vehicle on the Dentinal Tubule Penetration of Calcium Hydroxide and Triple Antibiotic Paste

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Abstract

Introduction: The purpose of this study was to evaluate dentinal tubule penetration (DTP) of calcium hydroxide (CH) and triple antibiotic paste (TAP) when performed with distilled water (DW) or a low surface tension liquid (ie, propylene glycol [PG]). **Methods:** Root apices of 40 single-rooted premolars were removed to obtain 14-mm roots in length. Root canals were enlarged to simulate immature teeth. After smear layer removal, the roots were randomly divided into 4 groups ($n = 10$) according to the root canal medicaments and the vehicles used: group 1:TAP + DW, group 2: TAP + PG, group 3: CH + DW, and group 4:CH + PG. Root canal medicaments were labeled with 0.1% rhodamine and applied into the canals using a Lentulo spiral. Specimens were molded into acrylic blocks, and 1-mm-thick sections were obtained from the middle third of each root. Specimens were mounted onto glass slides and scanned under a confocal laser scanning microscope. DTP depth, percentage, and area were measured using imaging software. Kruskal-Wallis and Mann-Whitney *U* tests were used for statistical analysis. The level of significance was set at $P < .05$. **Results:** No significant difference was found among the experimental groups in terms of both percentage and depth of DTP ($P > .05$). CH had a lower penetration area compared with TAP regardless of the vehicle used ($P < .05$). **Conclusions:** A low surface tension vehicle did not alter the penetration of CH and TAP. *(J Endod 2016;■:1–4)*

Key Words

Calcium hydroxide, propylene glycol, triple antibiotic paste, tubule penetration

Significance

This study showed that both propylene glycol and distilled water could be used as a vehicle and showed similar abilities for dentinal tubule penetration. A low tension vehicle is not necessary to carry the medicaments through the root canals.

Dental trauma can lead to pulp necrosis, which represents a clinical challenge in immature permanent teeth (1). Because of the incompletion of immature roots, a subsequent fracture and loss of tooth can occur (2). In this clinical scenario, the purpose of the endodontic treatment is to not only prevent and heal the apical periodontitis but also to promote continued root development and constitute the functional competence of the pulp tissue (3). To achieve this goal, revascularization is a biologically recommended treatment approach that allows thickening and lengthening of immature permanent roots (4).

The key procedure of revascularization is no mechanical instrumentation of the root canal while relying on gentle but thorough chemical disinfection (5). Previous studies have reported that sodium hypochlorite (NaOCl) irrigation alone is not sufficient to create a bacteria-free environment for revascularization of the infected necrotic tooth (6). Most recent studies have recommended the use of intracanal medicaments such as calcium hydroxide (CH) (7) or triple antibiotic paste (TAP) (ciprofloxacin, metronidazole, and minocycline) (8) for setting an environment suitable for revascularization.

Intracanal medicaments should penetrate deep into the dentinal tubules for complete elimination of intracanal bacteria and prevention of persistent infection (9). Several studies have reported the inefficacy of CH in eliminating bacterial cells inside the dentinal tubules (9, 10). By allowing the slow release of calcium and hydroxyl ions essential for therapeutic action and increasing the antibacterial properties (11), propylene glycol (PG) has been extensively used as a vehicle in CH paste. A previous study reported that PG provides more penetration of the dye compared with distilled water (DW) because of its low surface tension (12). However, no studies have reported the comparable effect of PG as a low surface tension vehicle on the penetration of CH and TAP. For this reason, the hypothesis of this study was that PG increases the penetration of CH and TAP through the dentinal tubules.

Materials and Methods

Specimen Preparation

Forty, single-rooted, straight human maxillary central incisors from 30- to 60-year-old patients (13) with mature apices were selected and stored in sterile saline solution until the experiments were performed. The apical portion of the root was resected to obtain a standardized length of 14 mm. Peeso reamers between #1 and #6 (1.50 mm) were used to enlarge the root apex by allowing them

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to protrude 1 mm beyond the root apex to simulate teeth with immature apices. The root canals were irrigated with 5 mL 17% EDTA (freshly prepared at the Department of Pharmacology, Hacettepe University, Sıhhiye, Ankara, Turkey) and 10 mL 2.5% NaOCl (ACE; Procter & Gamble Co, Istanbul, Turkey) to remove the smear layer and finally rinsed with 5 mL DW (14). The root canals were dried with paper points, and the external surfaces were dried by air blasting. All specimens were stored at 100% humidity during the experimental period. The specimens were then randomly assigned into 4 experimental groups (n = 10) according to the intracanal medicament and the vehicle used: group TAP + DW, group TAP + PG, group CH (Kalsin, Aktu Tic, Izmir, Turkey) + DW, and group CH + PG. TAP was prepared using 20 mg each of ciprofloxacin (Cipro 500 mg; Biofarma Pharm Ind Ltd, Istanbul, Turkey), metronidazole (Flagyl 500 mg; Sanofi Aventis Pharm Inc Co, Istanbul, Turkey), and minocycline (Minoz 50 mg; Ranbaxy Crosslands Laboratories Ltd, Nalagarh, India) and was mixed with 1 mL PG or DW. The intracanal medicaments were mixed with 0.1% rhodamine B (Sigma-Aldrich, St Louis, MO) as a fluorescence tracer for confocal laser scanning microscopic analysis. After preparation, the medicaments were delivered through the root canals until they appeared from the apex and up to the cervical line by using a #40 Lentulo spiral at 900 rpm. Then, the access cavities were sealed with a temporary filling material (Cavit W; 3M ESPE, Seefeld, Germany), and the samples were incubated at 37°C for 24 hours before analysis. Each specimen was embedded in a circular self-cure acrylic resin mold. One 1-mm-thick slice perpendicular to the long axis of each root was obtained from each specimen using a slow-speed, water-cooled 0.3-mm microtome saw (Isomet 5000; Buehler, Lake Bluff, IL) at 5 mm from the root apex. All specimens were mounted onto glass slides and scanned under a confocal laser scanning microscope (LSM Pascal; Carl Zeiss, Jena, Germany) using the 543-nm wavelength of a helium laser under 2.5× magnification (numeric aperture = 0.12). The pinhole was kept at 78 μm in all of the recordings. The first optical image section, which began at the surface of the specimen, was discarded. The next optical section, which was focused about 100 μm deeper, was acquired. The images were evaluated via LSM Image Examiner Software (Carl Zeiss) as in the previous studies (15, 16). In each sample image (Fig. 1), the circumference of the root canal wall and the circumference of the medicament penetration areas were outlined and measured using the software-measuring tool. The ratio of these 2 measurements (the circumference of the medication penetration areas/the circumference of the root canal wall) was calculated as the percentage of the medicament covering the canal wall. To measure the depth of penetration, the deepest point of penetration was measured from the canal wall to the point of the maximum medicament penetration. The penetration area of the medicament was calculated by the difference of the whole area of the medicament penetration and the measurement of the area of the canal. An overall comparison was performed with the Kruskal-Wallis test, and the Mann-Whitney U test was used for pair-wise comparisons. The level of significance was set at $P < .05$.

Results

According to statistical analysis, there was no significant difference among the experimental groups in regard to the percentage and depth of sealer penetration ($P > .05$). However, group CH + DW and group CH + PG revealed significantly less penetration areas compared with group TAP + DW ($P < .05$) and group TAP + PG ($P < .05$). Representative images from each group are presented in Figure 2, and statistical results belonging to all parameters are shown in Table 1.

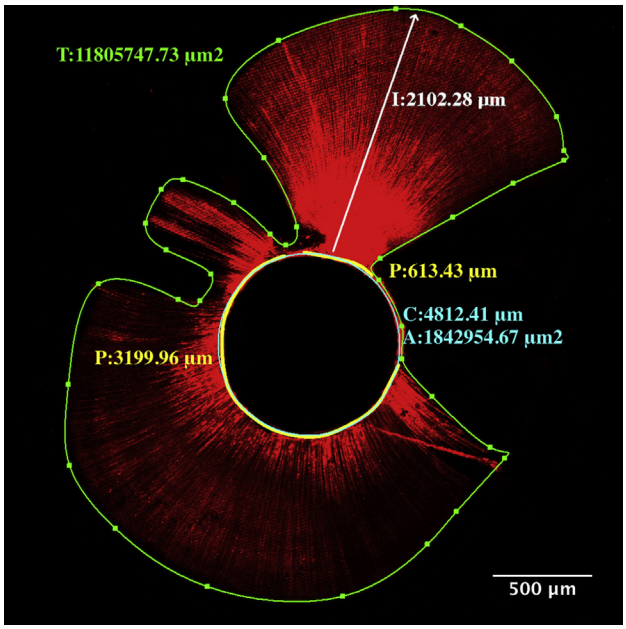

Figure 1. A confocal laser scanning microscopic image showing the measurement of percentage (P), maximum depth (I), and penetration area (T, A) of intracanal medicaments using LSM Image Examiner Software (Carl Zeiss) (2.5×, scale bar: 500 μm).

Discussion

An intracanal medicament should penetrate deeply and densely through the dentinal tubules for its antimicrobial activity and blockage effect to prevent reinfection (12). The tubule penetration of intracanal medicament depends on its surface tension; low surface tension provides more penetration into inaccessible areas (9). The present study investigated the penetration of 2 widely used intracanal medicaments using as a low surface tension vehicle. The findings showed that PG did not alter the penetration percentage, depth, and area of CH and TAP. Therefore, the hypothesis that PG increases the penetration of CH and TAP was rejected. The results showed that the penetration area of CH was found to be lower than that of TAP regardless of the vehicles used.

The revascularization procedure mainly depends on the creation of a bacteria-free environment inside of the root canal space using intracanal irrigants and intracanal medicaments (17). The present study determined DTP of the intracanal medicaments using confocal laser scanning microscopic analysis. This measurement method allows standard, reproducible, quick, objective, and 3-dimensional imaging without damaging the samples compared with scanning electron microscopy, which requires special material preparations (18). In the present study, visualization of penetration of the intracanal medicaments was confirmed by the presence of 0.1% rhodamine B as a fluorescent agent in the dentinal tubules (Fig. 3). This small amount of rhodamine B has no effect on the physical properties of the materials (19). Regarding the determination of DTP using confocal laser scanning microscopy, several studies have used the maximum penetration depth and percentage of sealer penetration as parameters (20, 21). The maximum penetration rate can provide the penetration measure in 1 point, whereas the percentage of penetration allows the evaluation of the penetration on the root canal walls not deep into the dentinal tubules. Thorough