

A comparison of the effectiveness of 17% EDTA and 6.25% pineapple peel extract in removing the smear layer in the apical third of the root canal

Perbandingan efektivitas EDTA 17% dan ekstrak kulit nanas 6,25% untuk menghilangkan lapisan smear pada sepertiga apikal saluran akar

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ABSTRACT

The smear layer is a thin layer consisting of organic and inorganic substances that can potentially cause microleakage. Therefore, the removal of the smear layer is crucial to the success of root canal treatment. This study compared the effectiveness of smear layer removal between 17% EDTA and 6.25% pineapple peel extract (PPE) (*Ananas comosus* L. Merr). A total of 32 upper premolars with intact crowns and root canals were divided into two groups: 17% EDTA and 6.25% PPE. The samples were prepared using the crown-down pressureless technique, rinsed according to their respective groups, and analysed for smear layer removal using SEM at 1000x magnification at the apical third of the root canal. A t-test revealed a significant difference in the effectiveness of smear layer removal between the two groups. Pineapple peel extract demonstrated superior performance in removing the smear layer at the apical third compared with 17% EDTA. It was concluded that 6.25% PPE is a promising alternative to 17% EDTA for root canal irrigation.

Keywords: smear layer, EDTA 17%, pineapple peel extract, root canal irrigation, apical third

ABSTRAK

Lapisan *smear* adalah lapisan tipis yang terdiri dari zat organik dan anorganik yang berpotensi menyebabkan *mikroleakage*. Karena itu, menghilangkan lapisan *smear* sangat penting untuk keberhasilan perawatan saluran akar. Penelitian ini membandingkan efektivitas penghilangan lapisan *smear* antara EDTA 17% dan ekstrak kulit nanas (EKN) (*Ananas comosus* L. Merr) 6,25%. Sebanyak 32 gigi premolar atas dengan mahkota dan saluran akar yang utuh dibagi menjadi dua kelompok: EDTA 17% dan EKN 6,25%. Sampel disiapkan menggunakan teknik *crown-down pressureless*, dibilas sesuai dengan kelompok masing-masing, dan dianalisis untuk pengangkatan lapisan *smear* menggunakan SEM pembesaran 1000x pada 1/3 apikal saluran akar. Uji-t menunjukkan adanya perbedaan yang signifikan dalam efektivitas penghilangan lapisan *smear* antara kedua kelompok. Ekstrak kulit nanas menunjukkan kinerja yang lebih unggul dalam membersihkan lapisan *smear* pada 1/3 apikal dibandingkan dengan EDTA 17%. Disimpulkan bahwa EKN 6,25% merupakan alternatif yang menjanjikan sebagai pengganti EDTA 17% untuk irigasi saluran akar.

Kata kunci: lapisan *smear*, EDTA 17%, ekstrak kulit nanas, irigasi saluran akar, sepertiga apikal

Received: 10 June 2026

Accepted: 15 July 2026

Published: 1 August 2026

INTRODUCTION

Endodontic treatment is one of the efforts to preserve teeth in the oral cavity, primarily aimed at cleaning necrotic tissues and micro-organisms from the root canal system to prevent reinfection.¹ The procedure involves three main stages known as the endodontic triad: access opening, preparation and cleaning, and obturation. During the preparation phase, mechanical instrumentation with endodontic files is combined with chemical irrigation to remove the smear layer formed during root canal preparation.² The smear layer, composed of organic components like bacteria and inorganic substances such as dentin debris and hydroxyapatite, can harbor bacterial colonies, hinder the penetration of medicaments, and impair the adaptation of sealers, potentially leading to microleakage. Its removal is therefore critical for improving medicament diffusion and preventing microleakage.^{3,4}

Among irrigation solutions, 17% ethylenediaminetetraacetic acid (EDTA) is widely recommended for smear layer removal due to its ability to demineralize dentin, expose the dentinal matrix, and enhance cell differentiation.³ However, concerns about its erosive effects on dentin have been highlighted, as 17% EDTA can alter the biomechanical properties, calcium-phosphate ratio, hardness, permeability, and solubility of dentin.^{5,6} These findings underscore the need for alternative irrigants with reduced erosive potential. Natural substances such as pineapple peel extract (*Ananas comosus* L. Merr) have emerged as promising alternatives due to their effectiveness, biocompatibility, and antibacterial properties. Active components such as flavonoids, tannins, saponins, and bromelain contribute to the extract's efficacy in removing the smear layer. Studies have shown that a 6.25% concentration of PPE is as effective, or even superior, to 17% EDTA in smear layer removal.^{7,8}

This research aims to evaluate the effectiveness of 17% EDTA and 6.25% PPE in eliminating the smear layer, with a specific focus on comparing their efficacy using ultrasonic agitation techniques. Insights from this study are expected to guide dental practitioners in selecting

alternative, efficient, and biocompatible irrigants for root canal treatment. By exploring these alternatives, the findings aim to enhance treatment outcomes and contribute to advancements in endodontic care practices.

METHODS

This study employed an experimental laboratory approach with a post-test-only control group design to evaluate the effectiveness of different irrigants in smear layer removal.

The study was conducted from February to March 2024 at several locations. Preparation of PPE was carried out at the Research Laboratory, Faculty of Medicine, Universitas Muslim Indonesia, Makassar. Root canal preparation was performed at the Conservative Dentistry Laboratory, Faculty of Dentistry, Universitas Hasanuddin. SEM photomicrograph analysis was conducted at the Microstructure Laboratory, Faculty of Engineering, Universitas Muslim Indonesia.

Samples

The study used 32 extracted maxillary first premolars with intact roots and crowns. The sample size calculation followed Federer's formula, namely $(n-1) \times (t-1) \geq 15$. Given that two treatment groups were used, with each group containing 16 samples, the total was 32. Inclusion criteria included maxillary first premolars with intact crowns and roots, no root caries, no root restorations, and completely closed apical foramina. Exclusion criteria involved teeth with root abnormalities, crown fractures, or dentin caries.

Materials and instruments

The instruments used included K-files, Protaper hand-use files, an ultrasonic irrigation unit, a scanning electron microscope (SEM), a rotary shaker/blender, a diamond separating disc, a caliper, and paper points. Materials included 6.25% PPE, 17% EDTA solution, red wax blocks, sterile distilled water, 96% ethanol, gloves, and masks.

Variables

The independent variables were 6.25% pineapple peel extract and 17% EDTA. The dependent variable was smear layer removal, and the control variable was the ultrasonic agitation technique.

Operational definitions

The 6.25% PPPE was prepared using 96% ethanol, followed by concentration adjustment with sterile aquadest. The 17% EDTA was a widely used root canal irrigant obtained from a chemical supplier. Ultrasonic agitation referred to the use of ultrasonic vibrations to enhance debris removal from root canals.

Data analysis was conducted using SPSS 27.0. Normality was assessed using the Shapiro-Wilk test, and homogeneity was tested with Levene's test. Differences between groups were evaluated with one-way Anova, followed by Tukey's test for post-hoc comparisons where appropriate.

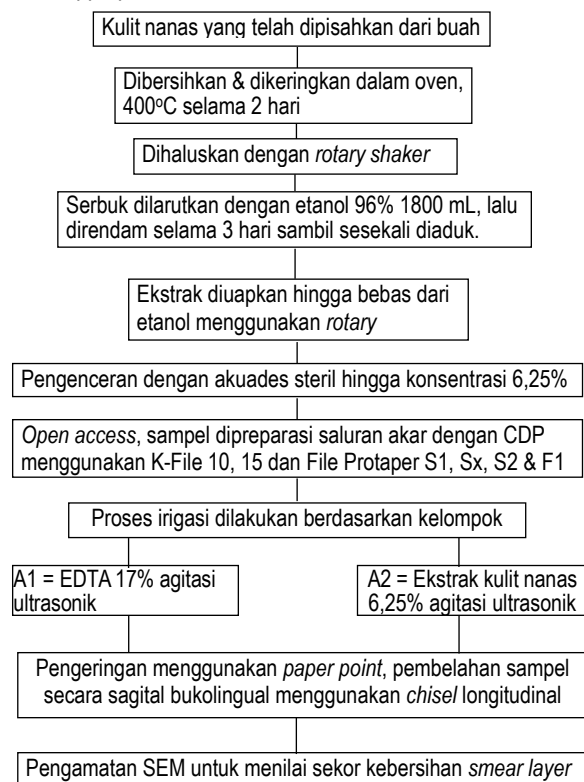


Figure 1 The procedure

RESULTS

Based on the results of the SEM examination at 1000x magnification, images of dentinal tubules and smear layers were obtained and evaluated by dividing each image into 9 equally sized sections. The evaluation was conducted by three experts in the field, with each expert assigning scores to each section. After the evaluation, the scores were totaled, and the average score for each sample was calculated (Fig.1).

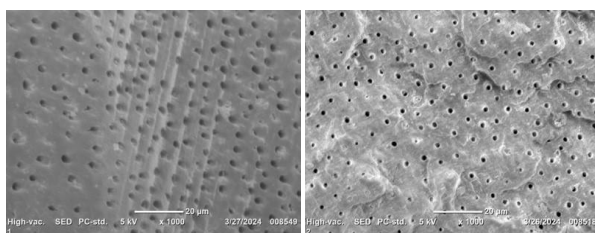


Figure 2 Group 1 the 6.25% pineapple peel extract

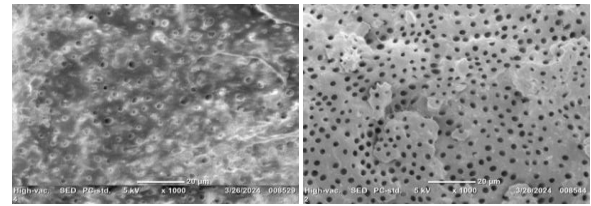


Figure 3 Group 2 the 17% EDTA

Descriptive analysis

Descriptive analysis is a statistical test used to analyze data by describing or summarizing the collecting data. This test aims to provide an overview of the variables based on the mean score and standard deviation (SD). The results indicate that the mean score for Group A was 1.48, while for Group B, it was 3.08. Additionally, the minimum and maximum scores for Group B were higher than those for Group A, suggesting that Group A demonstrated better performance in smear layer removal (Table 1).

Table 1 Descriptive statistics of SEM image scores

Group	Mean	Std. Dev	Minimum Value	Maximum Value
Group A (PPE)	1.48	0.26	1.19	1.80
Group B (EDTA 17%)	3.08	0.19	2.78	3.26

The Shapiro-Wilk test was conducted to assess data normality since the sample size was less than 50. The decision making process for this test utilized a probability-based approach with a significance level of 0.05. If the significance score (Sig.) was greater than 0.05, the assumption of normality was considered fulfilled. Conversely, if the significance score was less than 0.05, the assumption of normality was deemed unmet. Based on the normality test results in the table above, the significance value for Group A was 0.777, and for Group B, it was 0.464. These values are greater than the significance threshold of 0.05, indicating that the normality assumption was met (Table 2).

Table 2 Descriptive statistics of group data

Group	N	Sig.
Group A (PPE)	5	0.777
Group B (EDTA 17%)	5	0.464

The homogeneity of the data was tested using Levene's test, which was conducted on pretest and post-test data. The decision-making process was based on a probability approach with a significance level ($\alpha=0.05$). If the significance score (Sig.) exceeded 0.05, the homogeneity assumption was considered met; otherwise, it was not met. Based on the results of the homogeneity test, the significance value was 0.359 that is greater than the significance threshold of 0.05, indicating that the homogeneity assumption was met (Table 3).

Table 3 Levene's test results for homogeneity

F	df1	df2	Sig.
0.948	1	8	0.359

After fulfilling the prerequisites of normality and homogeneity tests, hypothesis testing was conducted using an independent sample t-test. The hypotheses proposed in this study were as follows: the null hypothesis (H_0) stated that there is no significant difference in the average measurement results between Control Group I and Control Group II, while the alternative hypothesis (H_1) proposed that there is a significant difference in the average measurement results between the two groups. The decision-making process in the t-test was based on a probability approach using a significance level of ($\alpha=0.05$). According to the decision rules, if the sig. is greater than 0.05, H_0 is accepted, whereas if the significance score is less than 0.05, H_0 is rejected.

Table 4 T-test results

t-value	df	Sig.
11.208	8	0.000

Based on the t-test results in the table above, the sig. value is 0.000, which is smaller than the significance level of 0.05. This indicates a significant difference in the average measurement results between Control Group I and Control Group II. Therefore, H_0 is rejected, and it can be concluded that the cleanliness level of Control Group I is better than that of Control Group II.

DISCUSSION

This study assessed the effectiveness of irrigation using PPE compared to EDTA 17%, based on Schafer's criteria for smear layer cleanliness in root canals. The results showed that the EDTA group had a mean of 3.08, classified as score 3 in Schafer's criteria, indicating that more than 50% of the root canal area had a widespread, uneven smear layer. In contrast, the pineapple peel extract group had a mean of 1.48, classified as score 1, which indicates the absence of smear layer with clearly visible dentin tubules. The minimum value for PPE was lower than that for EDTA 17%, suggesting that PPE was more effective in cleaning the smear layer in the apical third area.

The effectiveness of PPE is attributed to its active compounds. Flavonoids in the extract can interact with bacterial DNA, disrupting the lipid structure of the DNA and causing cell nucleus lysis.⁹ Additionally, tannins cause bacterial cell wall shrinkage, disrupting permeability and leading to bacterial death.¹⁰ Bromelain also alters the physical and chemical properties of cell membranes, inhibiting bacterial function. The saponins in PPE are effective in removing the inorganic components of the smear layer, such as calcium hydroxyapatite and tricalcium phosphate, through surfactant properties that reduce surface ten-

sion and form micelles.^{11,12}

These findings align with Pribadi et al.⁸ who demonstrated that PPE has a higher smear layer elimination capability than EDTA 17%. Maulidiyah³ suggested that PPE could serve as a better alternative to EDTA 17% for cleaning smear layers. Husniah,¹³ further noted that bromelain, polyphenols, and flavonoids in PPE assist saponins in cleaning smear layers by reducing the valency of calcium ions in the smear layer, making them more water-soluble. In contrast, EDTA can only remove the inorganic substances in the smear layer. To optimize elimination, EDTA is often combined with sodium hypochlorite (NaOCl), as recommended by Sumantri et al.¹⁴

The normality test showed a significance value of 0.777 for PPE and 0.464 for EDTA, both greater than 0.05, indicating that the data were normally distributed. The homogeneity test produced a significance value of 0.359, also greater than 0.05, indicating that the variances of the data were homogeneous. These tests fulfilled the prerequisites for conducting hypothesis testing.

Hypothesis testing revealed that PPE was significantly more effective than EDTA 17% in cleaning smear layers. Thus, the null hypothesis (H_0) was rejected, and the alternative hypothesis (H_1) was accepted, indicating a significant effect of PPE as the independent variable on the smear layer as the dependent variable. These findings support the initial hypothesis that PPE has the potential to be a superior irrigation material compared to EDTA 17%.

It is concluded that 6.25% PPE has a significantly better smear layer elimination capability compared to 17% EDTA, particularly in the apical third of the root canal. Given this finding, further research is recommended to explore the toxicity and biocompatibility of pineapple peel extract. These studies would help validate its potential use as an alternative irrigation material in dental treatments.

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