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The Effectiveness of Pagar Alam Green Tea Leaf Extract (*Camellia sinensis L.*) as an Irrigation Material on Smear Layer Removal

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Abstract

Introduction: The smear layer is a by-product of root canal instrumentation that may interfere with effective canal disinfection. Irrigation plays a crucial role in removing debris, microorganisms, and smear layer, particularly in the apical third, which is difficult to clean due to anatomical complexity. Pagar Alam green tea leaf extract (*Camellia sinensis L.*) has been proposed as a natural alternative irrigation material with potential smear layer removal properties. **Purpose:** To determine the concentration of Pagar Alam green tea leaf extract that effectively removes smear layer. **Methods:** This quasi-experimental study used 24 mandibular premolar teeth divided into four treatment groups. Root canals were prepared using the crown-down technique with hand ProTaper instruments and irrigated as follows: Group A: 25% Pagar Alam green tea leaf extract; Group B: 50% Pagar Alam green tea leaf extract; Group C: 2.5% NaOCl followed by 17% EDTA; and Group D: distilled water. The samples were sectioned longitudinally and evaluated under a measuring microscope at 1000× magnification using a visual scoring system. Data were analyzed using the Kappa test, Kruskal–Wallis test, and Mann–Whitney test. **Results:** There was no statistically significant difference in smear layer removal between Group B (50% Pagar Alam green tea leaf extract) and Group C (2.5% NaOCl and 17% EDTA) ($p > 0.05$). **Conclusion:** A 50% concentration of Pagar Alam green tea leaf extract is effective in removing the smear layer in the apical third of the root canal.
Keywords: *Camellia sinensis*; green tea extract; root canal irrigation; smear layer removal

Introduction

Pulp necrosis is commonly caused by deep dental caries, which create a pathway for bacteria to penetrate the pulp and reach the periapical tissues. This condition may lead to infection that spreads through the cancellous bone to the cortical bone.[1] Root canal treatment (RCT) is a therapeutic procedure aimed at treating pulp disease by removing vital or necrotic pulp tissue from the root canal system and replacing it with a root canal filling material. The primary objective of RCT is to prevent the spread of disease from the pulp to the periapical tissues and to preserve the affected tooth.[2] Failure of RCT is characterized by the recurrence of clinical symptoms accompanied by radiological evidence of periapical radiolucency.[3] One

contributing factor to RCT failure is inadequate root canal cleaning due to the presence of a smear layer. The smear layer is an irregular, amorphous layer with a thickness ranging from 1 to 5 µm that contains organic and inorganic debris, including bacteria, which can inhibit the penetration of antimicrobial agents into dentinal tubules and contribute to microleakage.[4–6]

Commonly used root canal irrigants include 2.5% sodium hypochlorite (NaOCl) which is effective in dissolving organic tissue but is toxic to periapical tissues and unable to completely remove the smear layer due to its limited action on inorganic components. In contrast, 17% ethylenediaminetetraacetic acid (EDTA) is used to remove inorganic material; however, its use may result in dentin demineralization and alterations in the biomechanical properties of the root canal dentin.[7,8] Therefore, the use of natural materials has been proposed as an alternative for root canal irrigation.

One herbal material in Indonesia with potential as an alternative root canal irrigant is green tea (*Camellia sinensis L.).* Green tea leaves contain various bioactive compounds, including saponins, flavonoids, alkaloids, and tannins, which exhibit antibacterial properties, suggesting that green tea extract may be suitable for use as a root canal irrigation material.[9] Indonesia possesses extensive biodiversity with numerous plant species that have potential medicinal value, including tea. Tea cultivation in Indonesia is primarily located in several regions, with Pagar Alam City recognized as an important production center where tea output increased from 2,589.00 tons in 2019 to 3,434.00 tons in 2020.[10] Tea is widely known for its antibacterial properties and is classified into green, white, oolong, and black tea based on the degree of fermentation. These tea types differ mainly in their polyphenol content, particularly catechins, which are most abundant in non-fermented teas. Green tea (*Camellia sinensis* L.) contains the highest levels of polyphenols and is rich in bioactive compounds such as flavonoids, saponins, tannins, and alkaloids, which contribute to its antibacterial activity. Flavonoids, as major polyphenolic compounds, are known to exhibit antioxidant, anti-inflammatory, antibacterial, and antiviral effects.[11]

Previous studies have reported the effectiveness of herbal ingredients in removing the smear layer. According to Mozartha, *Curcuma zedoaria* 10% and 20% can be considered effective as irrigation solutions, but with lower effectiveness compared to NaOCl 5.25%. [12] Ali reported that green tea was able to moderately remove debris in the middle and apical thirds of the root canal without causing visible erosion.[13] In addition, Mukherjee concluded that green

tea leaf extract was effective in removing the smear layer in the coronal and middle thirds of the root canal.[5] Furthermore, Asmah reported that Malino green tea extracts at concentrations of 15%, 50%, and 75% exhibited antibacterial effects against Enterococcus faecalis biofilm growth, with 75% concentration being more effective than 50%, and 50% more effective than 25%.[14] Study by Ramezanali revealed that Persian green tea showed acceptable antibacterial activity against *Enterococcus faecalis* biofilms.[15]

Based on these findings, this study aims to determine the effectiveness of Pagar Alam green tea leaf extract (*Camellia sinensis L.*) in concentrations of 25% and 50% as a root canal irrigation material in removing the smear layer.

Methods

Green tea leaf extract was obtained through a maceration process using 70% ethanol. A total of 3 kg of green tea leaves were first dried and then subjected to the extraction process.[12] The sample size was calculated using the Federer formula, resulting in six samples per group. In total, 24 samples were used and divided into four groups: Group A was irrigated with 25% green tea leaf extract, Group B with 50% green tea leaf extract, Group C with 2.5% NaOCl followed by 17% EDTA, and Group D with distilled water (Figure 1).

Figure 1. (A) 25% Pagar Alam green tea leaf extract, (B) 50% Pagar Alam green tea leaf extract, (C) 2.5% NaOCl , (D) distilled water

The samples were prepared using the crown-down technique with Protaper for hand use (FHU) instruments (Dentsply). Irrigation was performed for 1 minute at each file change according to the assigned group. After preparation, each sample was sectioned longitudinally into mesial and distal halves using a separating disc and chisel. The apical third was marked, and the specimens were mounted on a wax block to facilitate fixation during evaluation (Figure 2).

Figure 2. Illustration of sample embedding

The cleanliness of the apical third of the root canal was assessed using a measuring microscope by two independent observers and evaluated based on visual criteria, as demonstrated on Table 1.

Table 1. Visual evaluation criteria[16]

Score	Description
1	Little or no smear layer, covering <25% of dentinal tubules.
2	Slightly to moderate smear layer, covering 25% - 50% of dentinal tubules.
3	Moderate smear layer, covering 50% - 75% of dentinal tubules.
4	Severe smear layer, covering >75% of dentinal tubules.

Results

The results of this study were observed using a measuring microscope with 1000x magnification (Figure 3). Inter-observer agreement in assessing visual criteria was analyzed using the Kappa statistical test. The results showed a Kappa value of 0.936 with a p-value of 0.000, indicating a very good level of agreement between the two observers. These findings indicate that there were no significant differences between the assessments given by the

observers. Interobserver agreement in assessing the visual criteria was analyzed using the Kappa statistical test. The results showed a kappa value of 0.936 with a p-value of 0.000, indicating a very good level of agreement between the two observers. This finding suggests that there was no significant discrepancy between the assessments provided by the observers.

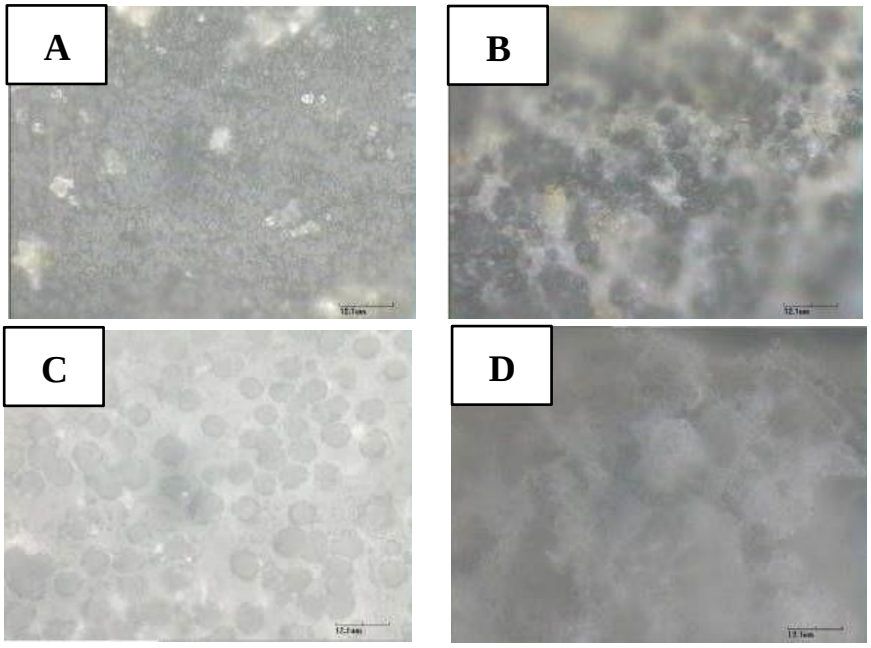

Figure 3. (A) Irrigated with 25% Pagar Alam green tea leaf extract, (B) Irrigated with 50% Pagar Alam green tea leaf extract, (C) Irrigated withNaOCl 2.5% and EDTA 17%, (D) Irrigated with distilled water

Subsequent analysis was performed using non-parametric statistical tests. The Kruskal–Wallis test was applied to determine whether there were significant differences in measurement outcomes among the treatment and control groups. The results showed a significance value (Asymp. Sig.) of 0.000. Since this value was less than 0.05, the null hypothesis (H) was rejected, indicating a significant difference between at least one treatment group and the others. The Mann–Whitney test was then conducted to identify which specific groups differed significantly, as presented in Table 2.

Table 2. Mann-Whitney test

	A	B	C	D
A	-	**0,045***	**0,015***	**0,000***
B		-	0,623	**0,000***
C			-	**0,000***
D				-

The Mann–Whitney post hoc analysis revealed significant differences among several treatment groups. A significant difference was observed between Group A (25% Pagar Alam green tea leaf extract) and Group B (50% Pagar Alam green tea leaf extract) (p = 0.045). Group A also showed a significant difference compared to Group C (2.5% NaOCl and 17% EDTA) (p = 0.015). In addition, a highly significant difference was found between Group A and Group D (distilled water) (p = 0.000).

No significant difference was observed between Group B (50% Pagar Alam green tea leaf extract) and Group C (2.5% NaOCl and 17% EDTA) (p = 0.623). However, Group B showed a significant difference compared to Group D (distilled water) (p = 0.000). Similarly, Group C demonstrated a significant difference when compared with Group D (p = 0.000).

Discussion

Root canal treatment (RCT) is a dental treatment procedure by removing vital or necrotic pulp tissue from the root canal which is then replaced with filling material.[2] One of the important step in this treatment is the removal of the smear layer using an irrigation material that functions to clean necrotic tissue, microorganisms, and debris in the tooth root canal.[6,7]

This study aimed to determine the effective concentration of Pagar Alam green tea leaf extract for smear layer removal. The effectiveness of the extract was evaluated using a measuring microscope to assess the condition of exposed dentinal tubules in the apical third of the root canal. Green tea contains saponins, which are capable of forming foam in aqueous solutions and reducing surface tension by disrupting hydrogen bonds in water. These properties give saponins detergent-like characteristics, enabling them to dissolve organic and inorganic debris.[11-13]

Based on the statistical analysis, irrigation with 25% Pagar Alam green tea leaf extract was insufficient to effectively remove the smear layer. In contrast, irrigation with a 50%

concentration resulted in little to no smear layer in the apical third, with dentinal tubules appearing open. Furthermore, no significant difference was observed between the 50% Pagar Alam green tea leaf extract group and the control group irrigated with 2.5% NaOCl and 17% EDTA. These findings indicate that Pagar Alam green tea leaf extract at a 50% concentration is effective in removing the smear layer during root canal treatment procedures. Higher concentrations of the extract provide increased antimicrobial effectiveness, as they contain higher levels of saponins capable of binding greater amounts of organic and inorganic debris by reducing surface tension on the root canal walls and more effectively dissolving microorganisms compared to the 25% concentration.[11,13,17] This result is consistent with the findings of Asmah (2023), who reported that Malino green tea leaf extract at a concentration of 75% was more effective than 50%, and that 50% was more effective than 25%.[14]

The control group irrigated with 2.5% NaOCl and 17% EDTA showed minimal smear layer presence, with dentinal tubules appearing open and free of debris. This outcome can be attributed to the combined action of NaOCl, which dissolves organic tissue, and EDTA, which removes inorganic components, allowing for effective smear layer removal when used together.[8,18] In contrast, the group irrigated with distilled water exhibited a large amount of smear layer, as distilled water has neutral properties and does not interact with organic or inorganic materials in the root canal, making it ineffective for smear layer removal.[19]

Several limitations were encountered in this study. The longitudinal sectioning of samples into mesial and distal halves using a separating disc posed a risk of debris entering the root canal during the cutting process. In addition, the small diameter of the root canal made microscopic evaluation challenging, resulting in some unclear images. Staining was also observed in samples irrigated with Pagar Alam green tea leaf extract, particularly at the 50% concentration, which may be attributed to the presence of polyphenols in green tea.[20] Residual extract within the root canal was also noted in the green tea groups, which may have influenced image clarity during evaluation.

Conclusion

Based on the results and discussion of this study, it can be concluded that a 50% concentration of Pagar Alam green tea leaf extract (*Camellia sinensis L.*) is effective in removing the smear layer in the apical third of the root canal.

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