A Comparative Evaluation of Phytic Acid as Final Rinse Solution with Other Chelating Agents for Elimination of Intraradicular Smear: A Scanning Electron Microscopy Study

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Aim: The aim of this study was to compare radicular smear layer removal ability of different solutions of phytic acid (PA) with other chelating agents when used in specific irrigant protocols. Materials and Methods: Seventy four maxillary central incisors were collected, standardized, and canals were prepared. A total of 5% sodium hypochlorite was used as the initial rinse solution (8mL). Samples were divided into control (Group I—normal saline and II—7% ethylenediaminetetraacetic acid) and experimental groups (Group III, IV, V, VI, VII, and VIII) based on the type of final rinse solution used, that is, 5% PA, 10% PA, 17% PA, 5% citric acid (CA), 10% CA, and 17% CA (5mL). Samples were coded, buccolingually divided into two halves, dehydrated, mounted, sputter coated, and examined under scanning electron microscope. Results: Group IV had the least smear and debris in coronal, middle, and apical thirds with mean scores of 1.06 and 1.3, respectively. When compared with Group II, no statistically significant difference was found (P > 0.05). Overall, the Group III had the lowest erosion scores at apical, middle, and coronal one-third with a mean of 1.68. Group VII had the highest amount of erosion with loss of peritubular and intertubular dentin at all levels. Conclusion: The role of PA as final rinse solution for the removal of radicular smear is promising and comparable to other chelating agents.

Keywords: Chelating agents, final rinse solution, irrigant solution, phytic acid, root canal irrigants, smear

INTRODUCTION

Biomechanical preparation procedure during endodontic therapy aims to prepare, cleanse the canal system, and eliminate microorganisms.[1] The smear formed during canal preparation contains both organic and inorganic constituents, and no single irrigant solution effectively removes both.[2] Biomechanical preparation can propel constituents of smear into radicular dentin for depths of up to 40 µm.[3-5] When surface active agents are used to enhance irrigant efficacy, capillary action, and adhesive forces further push smear for depths of up to 110 µm.[6-7] Different techniques have been suggested for effective smear elimination from canal ramifications.[8-9]

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Nygaard-Østby, in 1957, used chelating agents to negotiate calcified and narrow canals. They have been used as irrigant solutions aiming for removing inorganic constituents of smear by chelation. Ethylenediaminetetraacetic acid (EDTA) is popularly being used for smear removal in a concentration of 17%. It is also recommended for use as a lubricant during rotary instrumentation procedures. Chelating agents have found a definitive role in endodontic therapy as final rinse solutions as use of sodium hypochlorite alone has been inefficient in removing inorganic smear components. EDTA as a final rinse solution is very effective. Various irrigant solutions with properties of chelation have been experimented with. Citric acid (CA), etidronate (HEBP), and tetracycline have been found to be effective as chelating agents. Various synthetic chemicals used as final rinse solutions during biomechanical preparation when extruded beyond the apex even in minute quantities induce undesirable side effects and can harm periapical tissues. The hazards encountered due to the use of sodium hypochlorite have propelled investigators to look for safer, biocompatible alternatives. Natural substances when used for treatment have lesser side effects compared to synthetic drugs and less antibiotic resistance.

In 1855, inositol hexaphosphate (IP6) was identified, and it is found in nuts, legumes, whole grains, cereals, and seeds. It is an energy source for the germinating plants. IP6 has excellent properties of chelation and functions as an antioxidant by a process of chelating divalent cations, such as copper and iron. This prevents the generation of reactive oxygen species responsible for carcinogenesis and cellular damage. Animal studies have shown that IP6 is safe when administered in high doses for long periods. It has found a role as an implant coating for magnesium alloy where it improves corrosion resistance and stimulates new bone formation. It is also known as phytic acid (PA) and myo-inositol hexaphosphate.

**Materials and Methods**

Seventy-four extracted human permanent maxillary central incisors were collected, cleansed, and analyzed using radiovisiography. Teeth with mature, intact root apices were coded, standardized to 15 mm from apical tip, apical third covered with wax, and embedded in plastic cups filled with polyvinyl siloxane. This simulated in vivo closed apex conditions preventing irrigant extrusion beyond apex, and they were randomly divided into two control (n = 5) and six experimental groups (n = 8) [Table 1, Figure 1]. The canals were instrumented up to size F3 ProTaper rotary files (Dentsply Maillefer, Ballaigues, Switzerland) as per manufacturer instructions. A total of 8 mL was used as initial rinse. A total of 5 mL of the irrigant was used as final rinse as per the respective group for 3 min. The irrigant was delivered using a ProRinse 28-gauge side-vent needle (Dentsply, Tulsa Dental, Tulsa, Oklahoma) at working length.

During the first minute, needle was withdrawn 5 mm inserted back to working length followed by 180° rotation alternatively three times. A F2 size gutta-percha cone (Dentsply Maillefer) was inserted to working length and withdrawn six times (manual dynamic activation) during second minute to improve the irrigant replacement at apical third. After 3 min, a post final irrigation rinse of 10 mL of distilled water was carried out.

The teeth were divided into two halves in a buccolingual plane using diamond disc, and the half containing the most visible part of the apex was selected, coded, and stored. The split halves were placed in 10% neutral buffered formalin solution at 18°C for 24 h, post fixed in osmium tetroxide (1% wt/vol), and dehydrated in graded solutions of isopropyl alcohol (Nice Chemicals, Cochin, India). Separation markings of 5 mm were made for coronal, middle, and apical thirds, and samples were exposed to ultraviolet light in a sterilization chamber and stored in sterile pouches. They were mounted on aluminum stubs with carbon tape (Royal tapes, Chennai, India), sputter coated with a 20–30 nm thin layer of gold (Quorum, East Sussex, United Kingdom), examined using a scanning electron microscope with a high resolution (SIGMA 0336 Fesem, Zeiss, Munich, Germany). Images were obtained at ×2000 magnification using digital image analysis software and stored appropriately for subsequent analysis. Micrographs were recorded for each millimeter of specimen for coronal, middle, and apical thirds of root, and scoring was done by

| GROUPS (n= 5-8) | INITIAL RINSE | FINAL RINSE |
|-----------------|---------------|-------------|
| I - Negative Control (n=5) | Normal Saline | Normal Saline |
| II – Positive Control (n=5) | 5% NaOCl | 17% EDTA |
| III | 5% NaOCl | 5% Phytic Acid |
| IV | 5% NaOCl | 10% Phytic Acid |
| V | 5% NaOCl | 17% Phytic Acid |
| VI | 5% NaOCl | 5% Citric Acid |
| VII | 5% NaOCl | 10% Citric Acid |
| VIII | 5% NaOCl | 17% Citric Acid |
independent operators, compared, and tabulated. The smear, debris, and erosion were evaluated using criteria developed by Caron et al.,[18] Dadresanfar et al.,[19] and Torabinejad et al.,[20] respectively.

RESULTS

Group II (17% EDTA) and Group IV (10% PA) had least smear scores at the coronal, middle and apical thirds respectively [Figure 2]. At coronal and middle thirds, Group V (17% PA) was very effective and was as efficient as Groups II and IV at coronal and middle thirds. At apical third, it was less effective than Group IV. There was no significant difference between Groups II and IV (P > 0.05). In this study, Group II (17% EDTA) and Group VII (10% CA) presented least amounts of debris among all groups at the apical middle and coronal thirds, respectively. Group IV (10% PA) and Group VI (5% CA) were very efficient in removing debris at coronal and middle thirds [Figure 3]. There was no significant difference between the Groups II and VII (P > 0.05). Among experimental groups, Group VII (10% CA) had most values for erosion at the coronal, middle, and apical one-third, respectively. Group II (17% EDTA), Group IV (10% PA), and Group VII (10% CA) had comparable levels of erosion at all three levels [Figure 4]. Apical third of the root had the highest smear, debris and least values for erosion [Figure 5]. On statistical comparison and analysis, no significant difference was observed between the Groups IV and VII (P > 0.05) [Figure 6].

DISCUSSION

Removal of vital pulp and necrotic remnants, microbes, their by-products, smear, and debris is essential for successful outcomes of therapy. The rotary instruments act primarily in central lumen leaving isthmus, cul-de-sac of the canal system untouched. These areas due to inadequate cleansing, serve as a reservoir for microbial proliferation and impairs achieving a hermetic seal.[21,22] Smear layer elimination significantly enhances apical and coronal seal after obturation. It is independent of site of leakage, type of sealer, obturation technique, duration, and type of dye used for testing. Failure
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Figure 5: Mean scores – Apical, Middle and Coronal

Figure 6: Overall mean scores

Figure 7: Scanning electron microscopic comparison – Gp- II, V, VIII
to obtain a hermetic seal affects the prognosis and outcome of endodontic therapy.\textsuperscript{[23]}

Poor treatment outcomes are due to inadequate cleansing and persistent hidden infections within root canals. Sequential use of irrigant solutions during canal preparation has been advocated to eliminate microbes from within canals. These solutions have undesirable effects on periradicular tissues\textsuperscript{[24]} Irrigating solutions used during endodontic procedures need to be safe and biocompatible. A number of naturally derived substances have been tried as final rinses during endodontic therapy. This study evaluates a naturally derived chelating agent PA as a final rinse comparatively with other chelating agents. Microbial resistance is also a common issue encountered with the use of chemical irrigants repetitively. The natural derivatives have a vital role in these kinds of situations as being available as alternative safe, biocompatible, and nontoxic materials.

This study was conducted in maxillary central incisor teeth where canal preparation was standardized using a custom protocol. Custom prepared PA solutions of 5%, 10%, and 17% was compared with 17% EDTA, 5%, 10%, and 17% CA solutions for its efficacy as a final rinse solution.\textsuperscript{[10]} Group II and IV presented least amounts of smear among all groups. The Group V was also effective in removing smear and was as efficient on comparison with Groups II and IV at coronal and middle one-third of root. At the apical one-third, it was less effective than group IV. No significant difference was observed between Groups II and IV ($P > 0.05$). The CA groups were fairly efficient in removing smear at coronal and middle one-third. It was not as effective at apical thirds of root [Figure 7-9].

The selection of irrigant is of utmost importance in cleansing the canal system. Addition of surfactants, increasing irrigant temperature, volume, and activation has been advocated to improve irrigant efficacy. Use of two different irrigants in a sequence is commonly done to overcome shortcomings associated with the use of a single irrigant. Investigators tried out new methodologies and realized that combinations of irrigants were the most effective at smear layer removal, as per the concept of a working and a final irrigant solution.\textsuperscript{[25,26]} Sequential use of organic and inorganic solvents for smear elimination was tried as no single solution was effective in removing both organic and inorganic constituents. A total of 5% sodium hypochlorite solution and 17% EDTA were found to be most effective when used as initial and final rinses.\textsuperscript{[27]} Irrigant solution must be in contact with entire canal wall for a sufficient period to be effective. This

![Figure 8: Scanning electron microscopic comparison Gp- VI,III](image-url)
The use of PA as a final rinse solution in biomechanical preparation procedures during endodontic therapy is promising as it was found to be fairly effective at all thirds of the root canal. The results are comparable to 17% EDTA, which has been used widely as a final rinse solution. Being natural and biocompatible, PA seems an ideal candidate for use as a final rinse solution, and further studies, which explore other aspects of its viability as a final rinse solution and evaluation in a clinical setting, are recommended. This study was conducted in straight canals, and more difficult and challenging conditions would be present in posterior teeth, which have smaller root canals with more ramifications and curvature.

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Conflicts of interest
There are no conflicts of interest.

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