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Efficacy Of Novel Heat Treated Retreatment File System In Removing Gutta-Percha And Sealer From The Root Canal Walls- A Scanning Electron Microscope Analysis

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ABSTRACT

Objective: This study aimed to investigate the impact of solvents on the presence of gutta-percha and sealer remnants on root canal walls and inside dentinal tubules.

Methods: A total of 30 teeth were chemo mechanically prepared with an apical size of 30. In groups 1-3 (n = 10 each), the canals were filled with gutta-percha and sealer using matched single cone technique. The removal of root fillings was performed after 2 weeks using Solite RS3 endodontic retreatment files with three different solvents: group 1 (EDTA), group 2 (Xylene), and group 3 (GP Solv). After additional irrigation, the roots were split and subjected to scanning electron microscopy (SEM). The number of filled dentinal tubules (SEM) and the surface covered by root filling remnants were evaluated in the coronal, middle, and apical thirds of each root half. Statistical analysis was conducted using mixed models for clustered data, followed by Tukey's test.

Results: The control group A (EDTA) exhibited the lowest value of remnant GP followed by the Group B (Xylene) group and Group C (GP Solv) ($P < 0.05$ for all group comparisons). Moreover, the EDTA control group had fewer remnants than all other groups ($P < 0.05$).

Conclusion: The use of solvents resulted in higher remnants of gutta-percha and sealer on root canal walls and inside dentinal tubules.

Keywords: *Dentinal tubules, d-Limonene, endodontic retreatment, gutta-percha removal, scanning electron microscopy*

INTRODUCTION

With the increasing emphasis on tooth preservation and the management of post-treatment diseases following root canal treatment, conventional retreatment has gained significant attention. This procedure involves the removal of the existing root filling, further instrumentation, disinfection, and refilling [1,2]. Proper removal of the filling material is crucial to eliminate bacteria and facilitate the healing process. Thus, complete removal of the obturating material is vital for successful root canal retreatment. One key factor in retreatment is the complete removal of all endodontic material from the root canal system to achieve treatment goals [3]. Clearing the root canal wall of this material is essential for effective disinfection and retreatment. Various devices have been used to retrieve the obturating material, with rotary NiTi files being more effective and less laborious compared to conventional files. These rotary files are efficient in removing material and creating a tapered preparation. While successful removal of gutta-percha and sealer is crucial, the correlation between complete removal of root filling materials and the success of root canal retreatment is yet to be established. Nonetheless, it is essential to remove as much filling material as possible from inadequately prepared and/or filled root canal systems to uncover any remaining necrotic tissue or bacteria that may contribute to persistent diseases and allow for comprehensive chemomechanical reinstrumentation and disinfection of the root canal system [3] [4]. Various methods can be employed to remove root filling material, including endodontic hand files, engine-driven rotary instruments, heat-carrying devices, and ultrasonic devices [5–7]. Additionally, solvents can be used to soften and dissolve gutta-percha in the root canal, aiding in its penetration and removal. However, the effectiveness of solvents in gutta-percha removal remains inconclusive. Some studies have suggested that solvents like Xylene may reduce gutta-percha remnants and working time during retreatment [8], while others have found no significant difference [9]. Furthermore, the use of d-Limonene as a solvent has also shown no improvement in working time or canal wall cleanliness [10]. Following gutta-percha removal, the presence of open dentinal tubules becomes crucial for effective elimination of bacteria using irrigants. Studies have demonstrated bacterial invasion of dentinal tubules [11,12]. However, there is a lack of literature on the cleanliness of dentinal tubules after retreatment with solvents by the aid of novel heat treated retreatment file Solite RS3 using scanning electron microscopy (SEM). Previously our team has great experience in working on various research projects across multiple disciplines [13–27]. Now the current growing trends motivated us to pursue this project. Therefore, the objective of this study was to assess the presence of root filling material within dentinal tubules, visualized through SEM, and to evaluate the macroscopic remnants of root filling on the root canal surface after gutta-percha removal using different solvents such as Xylene and d-Limonene (GP Solv), as well as with Ethylene diamine tetraacetic acid (EDTA).

MATERIALS AND METHODS

Specimen Preparation

Thirty extracted human mandibular first premolar teeth were selected, and any soft tissue and calculus present on the root surfaces were carefully removed. Radiographic evaluation confirmed that the canals were clear and exhibited curvature angles ranging from 0 to 10 degrees. To initiate the experimental procedures, access cavity preparations were performed using Endo Access bur Size 1 (Dentsply Maillefer) and water spray. A size 10 K-type file was gently inserted into each canal until it became visible at the apical foramen. The working length was determined by subtracting 1 mm from the length at which the file was visible. The incisal edge of each tooth was adjusted to achieve a standardized working length of 18 mm. In order to capture specific areas for scanning electron microscopy (SEM) images, horizontal grooves were created on the root surfaces at distances of 2, 6, and 10 mm from the anatomical apex. This allowed for consistent positioning during the SEM analysis.

Root Canal Preparation

The root canals were prepared using ProTaper Gold rotary file systems (Dentsply, Maillefer) in accordance with the manufacturer's instructions. The crown-down technique was employed, starting with ProTaper Gold of sizes 20, 25, and 30, all having a progressive taper. The working length was reached using #10 K file. During the instrumentation process, irrigation was performed using 3% sodium hypochlorite (NaOCl). Subsequently, the root canals were rinsed with 17% ethylenediaminetetraacetic acid (EDTA) for 1 minute (5 mL) followed by 3% NaOCl (10 mL). To facilitate irrigation, a 28-gauge irrigation needle was inserted 1-2 mm short of the working length. Paper points were then used to dry all the root canals. The samples were randomly divided into three groups. The control group (group 1) consisted of 10 roots that used EDTA. The remaining groups (groups 2-3) each comprised 20 roots, which were subjected to further treatments or interventions.

Canal Filling

In all the groups, the root canals of each tooth were filled using the matched single cone technique with F3 master apical gutta-percha and tug-back was verified. The AH Plus sealer from Dentsply DeTrey (Konstanz, Germany) was used as a root canal sealer according to the manufacturer's instructions. The master cone was coated with sealer and placed into the canal. Additional gutta-percha cones of size 20 were used for lateral compaction using nickel-titanium finger spreaders of size 20. The spreaders were introduced until they could not penetrate more than 5 mm into the canal. The length of the root filling was limited to 14 mm from the apex, ensuring a nearly equal volume of gutta-percha for all roots. Radiographs were taken from different directions (buccolingual and mesiodistal) to confirm the quality and adequacy of the root filling. Temporary filling material Cavit G was placed in the access cavities. The teeth were then stored in a humidor at 37°C and 100% humidity for a period of two weeks to allow the complete setting of the sealer.

Retreatment Procedure

The cervical portion of the canal had 6 mm of the root filling material removed using Solite RS1 file. For the middle and apical parts of the canal, Solite RS2 and RS3 were utilized. An Endo Motor X-Smart Plus (Dentsply, Maillefer) was used at 300 rpm for Solite RS3 endodontic retreatment files instrumentation. In group 1, EDTA was used for gutta-percha removal. Group 2 utilized Xylene as a solvent, while group 3 used GP Solv. In each canal, 15 µL of solvent was applied four times, resulting in a total of 60 µL of solvent per canal. Throughout the reinstrumentation process, 3% NaOCl served as the irrigant. After the removal of gutta-percha, the canals were irrigated with 10 ml of saline. Lastly, all canals were dried using paper points.

Scanning Electron Microscope Analysis

The teeth underwent grooving using a hard tissue microtome and were subsequently split longitudinally. For SEM analysis, the specimens were dehydrated at 37°C for 7 days and then sputtered with gold using an SCD 050 Sputter Coater. The coronal, middle, and apical thirds of all root halves were examined using a SEM at a voltage of 10-15 kV and a standard magnification of 2000x. One image was taken at the position of each groove prepared on the root surface. The total number of dentinal tubules and the number of dentinal tubules either completely or partially filled with material were recorded for statistical analysis. The SEM images were performed by an operator who was blinded to the retreatment method used. The digital images were displayed on a 15-inch thin film transistor computer monitor operating at a resolution of 1024x768 and 16-bit color depth in a darkened room to minimize glare.

Statistical Analysis

The collected data were analyzed with IBM SPSS Statistics for Windows, Version 23.0 (Armonk, NY, IBM Corp, USA). Statistical analysis of data was performed using One-way ANOVA.

RESULTS

TABLE 1: Represents the mean and standard deviation of three groups namely; Group 1: EDTA, Group 2: Xylene, Group 3 : GP Solv. Remnants were found to be less in group 1 at all the levels followed by group 2. Along the column different superscript upper case alphabets showed significant difference to each other groups (p <0.05).

Groups	N	Mean ± Std.Dev Coronal Third	Mean ± Std.Dev Middle Third	Mean ± Std.Dev Apical Third
EDTA	10	0.455 ± 0.014^{A}	0.533 ± 0.092^{A}	0.147 ± 0.014^{A}
Xylene	10	0.601 ± 0.0778^{B}	0.622 ± 0.035^{B}	0.641 ± 0.064^{B}
GP Solv	10	0.761 ± 0.007^{C}	0.856 ± 0.042^{C}	0.795 ± 0.007^{C}
One way ANOVA		p=0.000	p=0.000	p=0.000

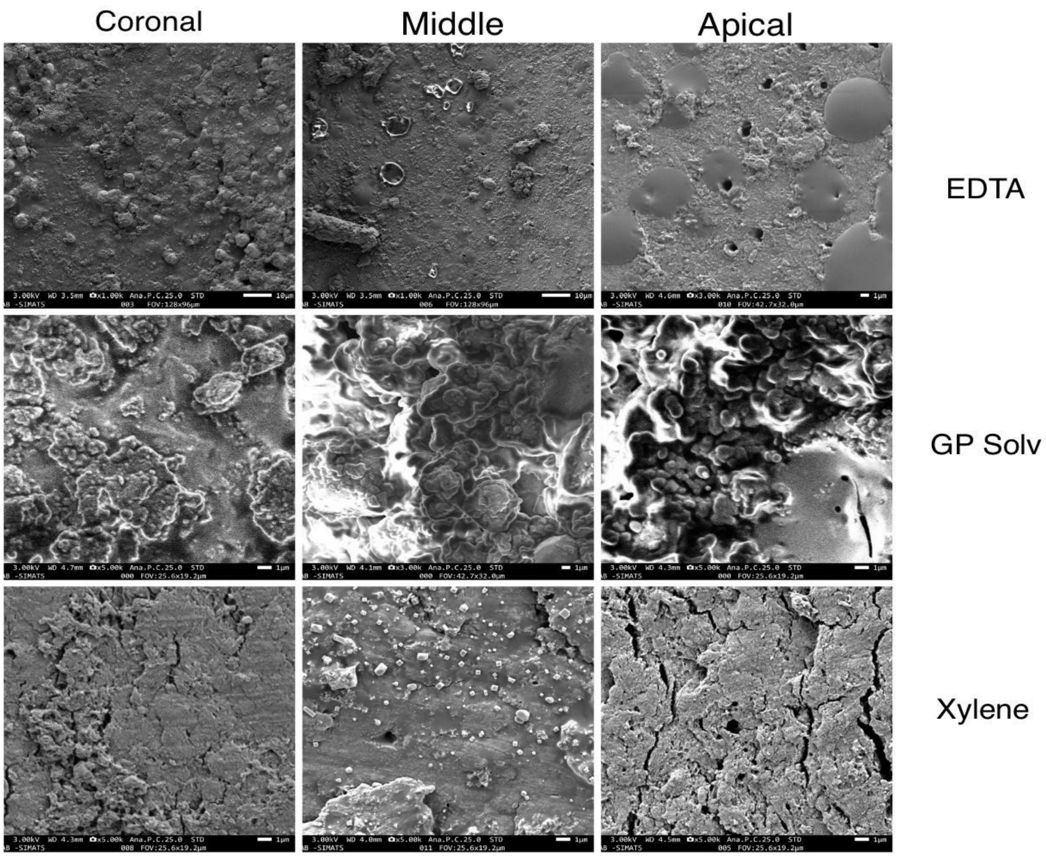

FIGURE 1: SEM images of Root canal walls in the coronal, middle and apical thirds of root canal following instrumentation using the solvents EDTA, GP Solv and Xylene (2000x).

DISCUSSION

Previous studies have focused on assessing gutta-percha remnants using radiographic evaluation or evaluation scales [8,9,28]. More recent studies have employed clearing techniques to measure the residual gutta-percha or sealer [29]. However, only few studies have utilized scanning electron microscopy (SEM) for this purpose [30]. The complete removal of root filling material from dentinal tubules is essential to eliminate bacteria responsible for post-treatment disease and facilitate proper irrigation. Additionally, remnants of root filling material can impact the adaptation and adhesion of sealers and cements used for posts. Xylene was selected as it is a common gutta-percha solvent [31]. Concerns have been raised regarding the evaluation of canal filling remnants using SEM, such as inadequate reporting of magnifications used in previous studies [32] , variations in magnification during the investigation [32,33], and potential operator bias in image selection [34]. To address these concerns, this study standardized the magnification at 2000x for all images and evaluated the results considering the specific root parts where the images were captured. Grooves in the root surface were employed to define the investigation area, minimizing operator bias. Each tooth underwent up to six repeated measures, considering both tooth halves and the coronal, middle, and apical thirds. To account for within-teeth dependency, a mixed model analysis was applied. However, due to tubular sclerosis and/or artifacts, open dentinal tubules could not be evaluated in all SEM images. Tubular sclerosis, a phenomenon starting in the apical part of the root canal and progressing coronally with age, likely contributed to the lower number of evaluated samples in the apical third compared to the middle and coronal thirds. The age of the specimens, obtained from a tooth bank, could not be controlled, potentially influencing the presence of patent tubules. The SEM analysis demonstrated a significantly higher number of open tubules in the apical third compared to the middle third of the root canal. In this study, preparation of straight canals involved using files two sizes larger than the initial preparation. Moreover, previous studies did not utilize SEM to visualize dentinal tubule debris. SEM analysis consistently revealed a higher presence of dentinal tubule debris compared to the macroscopic evaluation of surface remnants, emphasizing that surface evaluation alone cannot fully capture the extent of debris within the tubules. None of the tested techniques achieved complete removal of the root filling material, aligning with previous findings [35–37]. More remnants were observed in irregularities of the root canal wall and within dentinal tubules as the root filling material dissolved. Softened filling material had a tendency to compact into these irregularities and tubules, making complete removal challenging. This effect was more pronounced in the solvent groups, particularly the GP Solv group, compared to the EDTA group. The higher solubility of gutta-percha in Xylene and GP Solv would have resulted in dissolution of GP and generation of frictional heat which causes GP to adhere to the root canal walls whereas with the use of EDTA, reduces the friction generated and facilitates complete removal of GP without adhesion of GP to the canal walls [38,39]. Notably, the remaining filling material rarely completely obstructed the cross-section of the dentinal tubules. This may be attributed to the dissolution of the material by the solvent, although similar observations were made in the nonsolvent group. Another possibility is that the gutta-percha/sealer "tags" were partially displaced from the tubules during instrumentation, influenced by the cutting edges' motion. This study highlights the importance of evaluating dentinal tubules and comparing the effectiveness of solvents in removing gutta-percha during root canal retreatment. SEM analysis provides valuable insights into the presence of debris within the tubules, complementing the macroscopic evaluation of surface remnants. Although complete removal of the root filling material was not achieved, solvents demonstrated potential in enhancing gutta-percha dissolution. Rotary instruments are favored over hand instruments in retreatment procedures as they effectively plasticize the gutta-percha through friction, facilitating its easy removal. Rotary instruments also tend to reduce operator fatigue, working time, and help maintain the canal shape [40,41]. In the present study, a novel file system called Solite RS3 retreatment files were utilized. Solite retreatment files come in three different tapers, lengths, and color codes for easy identification. The three files are RS1 (blue), RS2 (red), and RS3 (yellow). RS2 and RS3 files are heat treated, enabling them to flex through the canal systems. The study results indicated that the root canal cleanliness using Solite files for gutta-percha retrieval with the solvent GP Solv had more remnants of GP and sealer, although there was no significant difference between Xylene and EDTA. This could be attributed to the composition, properties of solvents used , the flexibility of the Solite files and their reduced stiffness due to heat treatment, which may have affected the speed of gutta-percha removal using different solvents. By presenting these findings, the study contributes to the understanding of the performance of different solvents used in root canal retreatment and provides insights into choosing the right solvent and their potential advantages and considerations when using the Solite RS3 retreatment files.

CONCLUSION

The use of solvents in endodontic retreatment resulted in an increased presence of gutta-percha and sealer remnants both on the root canal walls and inside dentinal tubules. Therefore, the routine use of solvents during retreatment should be reconsidered, and they should only be utilized when it is necessary to reach the working length.

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