Comparative Evaluation Of Three Different Retreatment File Systems In Removing Gutta-Percha And Bioceramic Sealer From Root Canal Walls A Scanning Electron Microscopic Study

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ABSTRACT

Objectives:

The aim of this study was to compare and evaluate the efficacy of three different retreatment file systems in the removal of gutta-percha and bioceramic root canal sealer from root canal walls using scanning electron microscopy (SEM).

Materials and methods:

Thirty extracted human single-rooted premolars were selected, cleaned, and stored in 0.1% thymol solution. All specimens were decoronated to standardize root length and prepared up to F3 using ProTaper Gold files. Canals were obturated with gutta-percha and Bio-C sealer using a single-cone technique. After storage at 37°C and 100% humidity for two weeks, samples were randomly divided into three groups (n=10) based on the retreatment system used: Group I—ProTaper Universal Retreatment, Group II—HyFlex Remover, and Group III—D-Perfect Retreaty. Retreatment procedures were performed according to manufacturer instructions. All specimens were longitudinally sectioned and evaluated under SEM at coronal, middle, and apical levels. Debris scores were recorded and analyzed using one-way ANOVA and Tukey post hoc test.

Results: Group II showed significantly less residual debris in the coronal third (1.60 ± 0.52), followed by Group I (1.70 ± 0.48), whereas Group III showed the highest debris scores (3.50 ± 0.53). In the middle third, Group I demonstrated the least debris (1.80 ± 0.42), followed by Group II (2.00 ± 0.67), while Group III again showed the highest values (3.00 ± 0.67). At the apical third, Group II showed the lowest debris scores (2.60 ± 0.52), whereas Group I (3.40 ± 0.52) and Group III (3.50 ± 0.53) showed higher residual material. Statistically significant differences were observed among all groups at coronal and middle levels ($p<0.001$) and at the apical level ($p=0.001$).

Conclusion: None of the retreatment systems achieved complete removal of gutta-percha and bioceramic sealer from the root canal walls. Group II demonstrated superior cleaning efficiency in the coronal and apical thirds, whereas Group I performed better in the middle third. Group III showed the least cleaning efficiency at all levels. Adjunctive techniques such as the use of ultrasonics may be required to enhance the removal of obturation materials during retreatment.

Clinical significance: Residual obturation material persists irrespective of the retreatment system used and may compromise disinfection and treatment outcome. Therefore, the use of effective retreatment systems in combination with adjunctive techniques is essential for improving canal cleanliness and retreatment success.

Keywords: Endodontic retreatment, bioceramic sealer, gutta-percha removal, SEM analysis, retreatment systems

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INTRODUCTION

Endodontic failure may result from multiple factors, including persistent intraradicular infection, incomplete obturation of the root canal system, overextension of filling materials, inadequate coronal seal leading to microleakage, missed canals, and various procedural errors.[1]

Non-surgical endodontic retreatment is the treatment of choice in such cases and involves removal of the existing obturating material, followed by re-cleaning, shaping, and obturation to re-establish periapical health. Complete removal of gutta-percha and sealer is essential to allow irrigants and medicaments to effectively penetrate the root canal system. However, due to adhesion to canal walls and penetration into irregularities, complete elimination of obturation material remains a significant challenge, and remnants often persist despite thorough instrumentation.[2,3]

Conventional methods for gutta-percha removal, including hand instrumentation, heat, and the use of solvents such as chloroform, xylene, and orange oil, are often time-consuming and technique-sensitive. Although solvents facilitate softening of gutta-percha, they do not ensure complete removal and may adversely affect dentin structure and bonding during re-obturation.[4]

The introduction of rotary nickel–titanium (NiTi) retreatment systems has improved the efficiency and predictability of retreatment procedures. ProTaper Universal Retreatment files are widely used due to their progressive taper and active cutting design, enabling effective removal of filling materials from different canal levels[5]. HyFlex Remover, a single-file system made of controlled-memory NiTi alloy, offers enhanced flexibility and adaptability, allowing efficient removal of obturating materials with minimal canal transportation[6]. The D-Perfect retreatment system is a newer single-file system designed for efficient gutta-percha removal. It consists of five distinct systems fabricated from three

different alloys, utilizing two types of rotary motions and a single cross-sectional design. Each instrument is uniquely identified by avatar-based names instead of conventional coding[7]; however, literature regarding its performance, especially in combination with bioceramic sealers, remains limited.

Bioceramic sealers, such as Bio-C Sealer, have gained popularity due to their biocompatibility, bioactivity, and ability to chemically bond with dentin. However, these same properties make their removal during retreatment more difficult, as they exhibit strong adhesion and penetration into dentinal tubules. This raises concerns regarding their retrievability and the effectiveness of retreatment systems in eliminating them completely.[8,9]

Evaluation of residual obturation material is essential to assess the efficacy of retreatment systems. Scanning Electron Microscopy (SEM) provides high-resolution imaging and allows detailed visualization of dentinal surfaces, enabling accurate assessment of remaining debris and sealer.[10]

Therefore, the present study aimed to compare the efficacy of three retreatment file systems—ProTaper Universal Retreatment, HyFlex Remover, and D-Perfect—in removing gutta-percha and bioceramic root canal sealer from root canal walls using SEM analysis.

MATERIALS AND METHOD

This in vitro study was conducted in the Department of Conservative Dentistry and Endodontics, Geetanjali Dental and Research Institute, Udaipur, Rajasthan. Ethical approval was obtained from the Institutional Ethical Committee.

Selection and Preparation of Teeth

A total of 30 extracted human single-rooted premolar teeth were selected based on predefined inclusion and exclusion criteria. The collected teeth were cleaned of soft tissue remnants and calculus using an ultrasonic scaler and stored in 0.1% thymol solution until use.

The specimens were decoronated at the cemento-enamel junction using a diamond disc to standardize root length. Access cavities were prepared using round carbide burs followed by Endo Access burs under water cooling to achieve straight-line access.

Working Length Determination

Canal patency was established using a #10 K-file. The working length was determined by inserting the file until its tip was visible at the apical foramen, and 1 mm was subtracted from this length.

Cleaning and Shaping

Biomechanical preparation was performed using the ProTaper Gold rotary system in a crown-down technique up to size F3, according to the manufacturer's instructions. Glyde was used as a lubricant during instrumentation.

Irrigation was performed with 5.25% sodium hypochlorite between each instrument. After completion of instrumentation, a final rinse with 17% EDTA for one minute was carried out to remove the smear layer, followed by saline irrigation.

Obturation

The canals were dried using sterile paper points and obturated with F3 gutta-percha cones along with Angelus Bio-C sealer using a single-cone technique. The access cavities were sealed with a temporary restorative material.

Storage

All specimens were stored at 37°C in 100% humidity for two weeks to allow complete setting of the bioceramic sealer.

Retreatment Procedure

30 specimens were randomly divided into three groups of 10 teeth each depending on the retreatment file system used.

Group I: n=10 (ProTaper universal retreatment files)

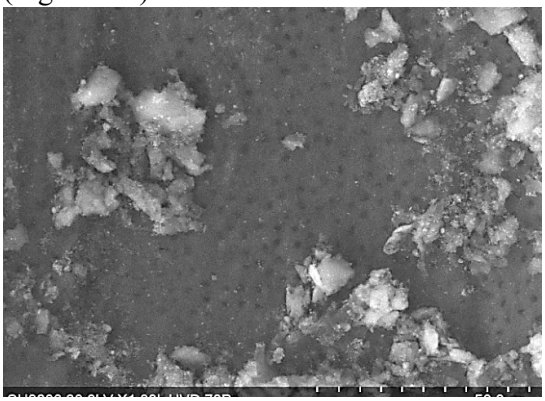
The ProTaper Universal Retreatment system was operated at a speed of 400–500 rpm with a torque of 3 Ncm. The coronal third of the canal was instrumented using the D1 file (30/0.09), followed by D2 (25/0.08) and D3 (20/0.07) files for the middle and apical thirds, respectively. Instrumentation with the D3 file was continued up to the working length until no visible remnants of obturating material were observed on the file flutes upon withdrawal.[7]

Group II: n=10 (HyFlex Remover)
Retreatment was performed using the HyFlex Remover file system in continuous rotary motion. Initial coronal enlargement was carried out using a file with a tip size of 25/.09 and a length of 17 mm. Subsequently, a second file with a tip size of 30/.07 and a length of 19 mm was used to remove the obturating material, progressing up to 3 mm short of the working length. The instrumentation was carried out at a speed of 400 rpm and a torque of 2.5 Ncm, in accordance with the manufacturer's recommendations.[6]
Group III: n=10 (D-Perfect Retreaty System)
Instrumentation was carried out at a speed ranging from 350 to 500 rpm with a torque of 1.5–2.5 Ncm. The Bull-Y file (25/.07), composed of gold heat-treated alloy with a semi-active tip, was initially used at the canal orifice to engage and remove gutta-percha from the coronal third using either continuous rotary or reciprocating motion (30° counterclockwise/150° clockwise).
The Skinny file (24/.04), a non-heat-treated instrument with a semi-active tip, was subsequently used in the middle third, advancing 1–3 mm into the canal using a gentle in-and-out motion to facilitate removal of obturation material.
Following a crown-down approach, Shap-Y1 (20/.05) and Shap-Y2 (25/.05), both heat-treated instruments, were used sequentially to prepare the canal up to the working length without applying a brushing motion.
When additional apical enlargement was required, Shap-Y3 (30/.04, blue heat-treated file) was used to complete the preparation.[7]
Between each instrument change, irrigation was performed using 5.25% sodium hypochlorite and 17% EDTA. Retreatment was considered complete when no visible filling material remained on the instrument flutes and the working length was reached.
Assessment of Retreatment
All the specimens were longitudinally sectioned in the buccolingual direction using a diamond disc under continuous water cooling. The samples were carefully split into two halves, and each half was coded for identification. The specimens were then examined under a scanning electron microscope (SEM), and photomicrographs were obtained at different magnifications.
The evaluation of residual obturating material was carried out in the coronal, middle, and apical thirds of the root canal. The amount of remaining gutta-percha and sealer on the canal walls was assessed qualitatively based on a scoring system.
Scoring Criteria
The SEM images were evaluated and scored according to the criteria described by Ezzie et al.[2], as follows:
• Score 0: 0–25% of dentinal surface covered with residual obturating material
• Score 1: 25–50% of dentinal surface covered with residual obturating material
• Score 2: 50–75% of dentinal surface covered with residual obturating material
• Score 3: 75–100% of dentinal surface covered with residual obturating material.
Statistical Analysis
The data obtained were statistically analyzed using SPSS software (version 26.0, IBM Corp., Armonk, NY, USA). The mean values of residual debris among the three groups at different canal levels were compared using one-way analysis of variance (ANOVA), followed by post hoc analysis for multiple comparisons. A p-value < 0.05 was considered statistically significant.

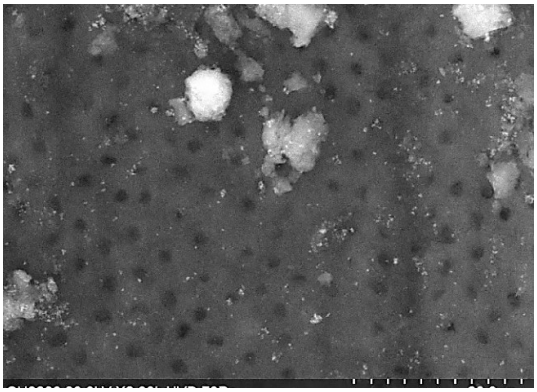
RESULTS

At the coronal third of the root canal, Group II demonstrated the highest efficiency in removing residual obturating material, followed by Group I, whereas Group III showed the least efficiency. At the middle third of the root canal, Group I demonstrated the highest efficiency in debris removal, followed by Group II, while Group III again showed the least efficiency. At the apical third of the root canal, Group II showed the highest efficiency in removing obturating material, followed by Group I, whereas Group III demonstrated the least efficiency. None of the retreatment files were able to remove debris in the root thirds

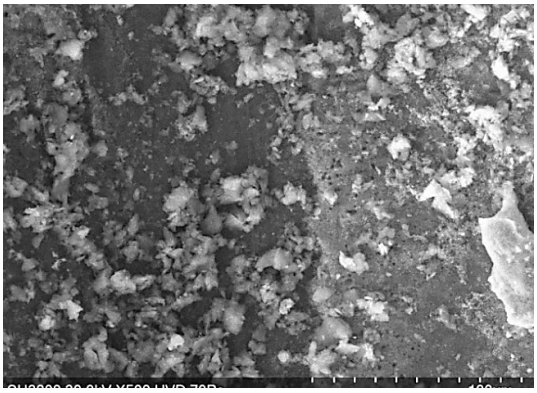
completely, regardless of the file system used. (Figure 1-3)



Coronal

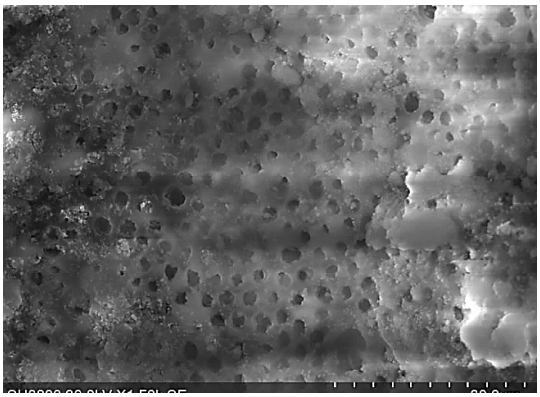


Middle

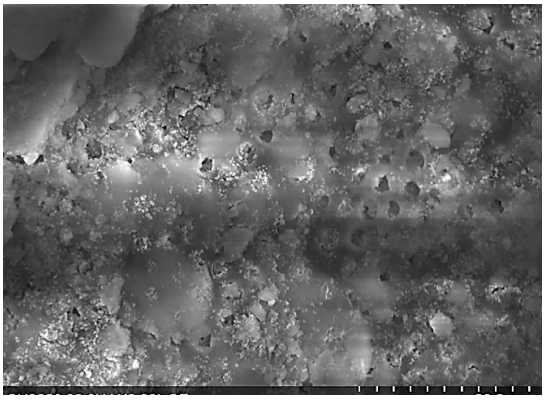


Apical

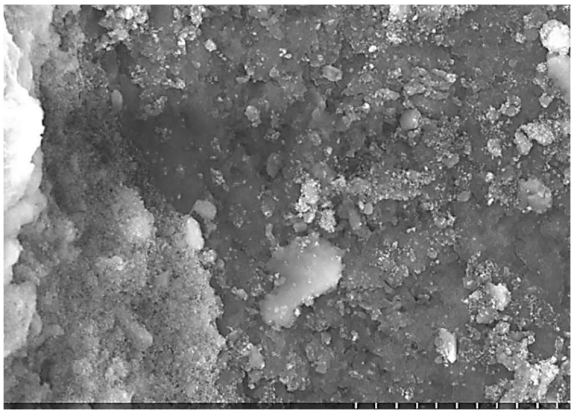
Figure 1 : SEM images of Group I (Coronal, Middle and Apical of the root canal)



Coronal

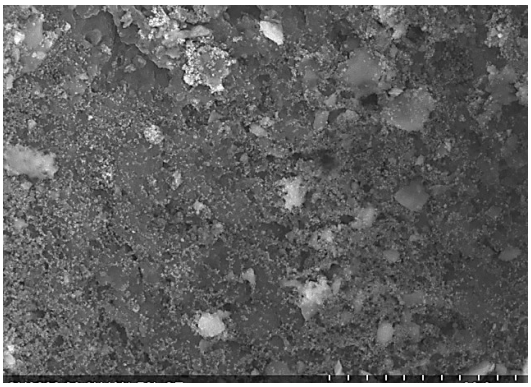


Middle

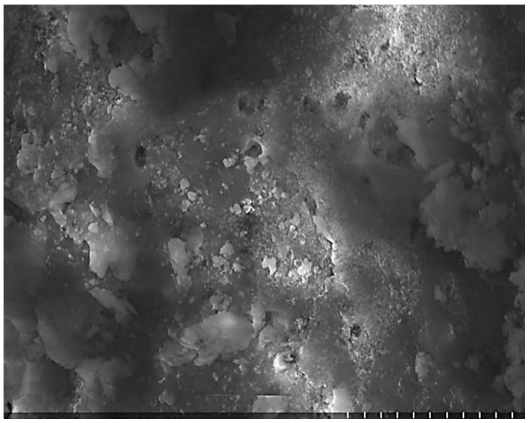


Apical

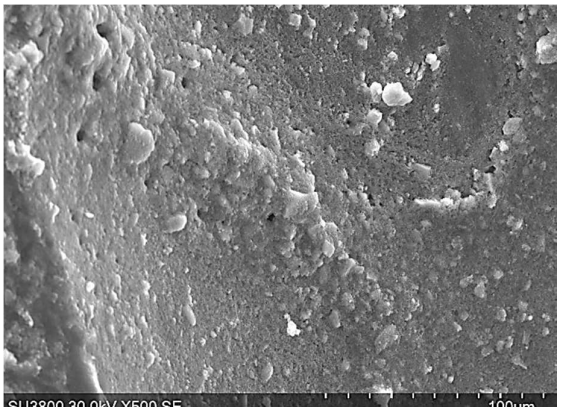
Figure 2 : SEM images of Group II (Coronal, Middle and Apical of the root



Coronal



Middle



Apical

Figure 3: SEM images of Group III (Coronal, Middle and Apical of the root canal)

Post hoc intergroup comparison was done for all three groups at coronal, middle and apical thirds of the root canal. Significant differences were observed between Group III and Group I and Group III and Group II at the coronal third, Groups III and II and Group III and Group I at the middle thirds, whereas at the apical third, significant differences were noted between Groups I and Group II, Group II and Group III. No significant difference was observed between Groups I and II at the coronal and middle thirds, and between Groups I and III at the apical third. (Table 1)

Table 1: Comparative assessment of mean debris scores among three retreatment file systems at coronal, middle and apical third of root canal.

Groups	Debris score (Mean ± SD)		
	Coronal third	**Middle third**	**Apical third**
ProTaper Universal Retreatment (Group I)	1.70 ± 0.48[a]	1.80 + 0.42[a]	3.40 ± 0.52[a]
HyFlex Remover (GroupII)	1.60 ± 0.52[b]	2.00 + 0.67[b]	2.60 ± 0.52 [ab]
D-Perfect (Group III)	3.50 ± 0.53[ab]	3.00 + 0.67[ab]	3.50 ± 0.53[b]
p-value	0.000*	0.000*	0.001*

Test applied: One way ANOVA with post Hoc Tukey, *indicates statistically significant difference.

Post Hoc test: Values with same letter superscripted shows statistically significant difference

DISCUSSION

Endodontic retreatment plays a crucial role in the management of previously treated teeth with persistent or recurrent disease. The primary objective is the complete removal of existing obturating materials to facilitate effective chemo mechanical debridement and subsequent re-obturation of the root canal system. However, complete elimination of filling material remains a clinical challenge, particularly in the apical third and in anatomically complex canal systems . [11]

The introduction of nickel–titanium (NiTi) rotary instruments has significantly enhanced retreatment efficiency due to their superior flexibility, cutting ability, and ability to

maintain canal anatomy. The ProTaper Universal Retreatment system, with its progressive taper and active cutting design, facilitates effective engagement and coronal transportation of gutta-percha. Similarly, HyFlex Remover, a heat-treated controlled memory file, exhibits improved flexibility and centering ability, allowing better adaptation to canal irregularities while preserving dentin[6]. The D-Perfect Retreaty system, with its combination of different heat-treated alloys and sequential file design, aims to provide a minimally invasive yet efficient retreatment approach.[12]

Apart from instrument design, the type of sealer used plays a significant role in retreatment difficulty. Conventional epoxy resin–based sealers such as AH Plus exhibit mechanical adhesion to dentin through polymer infiltration into the tubules[13]. In contrast, bioceramic sealers demonstrate chemical and micromechanical bonding with the dentinal surface, which increases the difficulty of their removal during endodontic retreatment procedures. Furthermore, the increased hardness of these sealers after setting may enhance their adherence and resistance to dislodgement from dentin, thereby making their removal during secondary endodontic treatment more challenging.[14]

In the present study, none of the retreatment systems achieved complete removal of obturation material, which is consistent with previous findings that complete elimination of gutta-percha and sealer is virtually impossible irrespective of the technique used. At the coronal third, Group II demonstrated superior efficiency, followed by Group I, whereas Group III showed the least efficiency. At the middle third, Group I performed better, followed by Group II, while Group III again showed reduced efficiency. At the apical third, Group II demonstrated better performance compared to the other groups; however, residual material persisted in all groups.

The superior performance of ProTaper Universal Retreatment files in the coronal and middle thirds can be attributed to their progressive taper and active cutting design, which enhances engagement and removal of obturation material. However, their reduced adaptability in the apical third may contribute to residual debris in this region[15,16]. HyFlex Remover demonstrated effective debris removal, likely due to its higher flexibility, controlled memory alloy, and increased buckling resistance, which allows better penetration into gutta-percha and adaptation to canal anatomy. Nevertheless, its reduced taper in the apical region may limit its cutting efficiency in deeper areas.[6,17]

The persistence of obturating material in the apical third across all groups can be attributed to multiple factors, including complex canal anatomy, accessory canals, and deeper penetration of bioceramic sealers into dentinal tubules. Mechanical instrumentation primarily affects the superficial layers of the canal wall, while deeper remnants remain largely unaffected. Scanning electron microscopy was used in the present study due to its high resolution and ability to provide detailed visualization of residual debris and dentin surface morphology. It allows accurate qualitative and quantitative assessment of obturation remnants at different canal levels, making it a reliable method for evaluating retreatment efficacy.[10]

From a clinical perspective, the presence of residual obturation material can interfere with the penetration of irrigants and compromise the adaptation of new filling materials, thereby affecting treatment outcomes. Therefore, complete removal of obturation material is essential to enhance disinfection and improve the long-term success of retreatment procedures.[1,2]

The findings of the present study also highlight that mechanical instrumentation alone is insufficient for complete removal of obturation material, particularly when bioceramic sealers are used. Adjunctive techniques such as sonic or ultrasonic activation of irrigants can significantly enhance cleaning efficiency by improving irrigant penetration and facilitating the removal of debris from inaccessible areas.[18]

Thus, although rotary retreatment systems improve the efficiency of gutta-percha and sealer removal, complete elimination remains challenging. The adjunctive use of irrigant activation techniques is recommended to achieve better canal cleanliness and improve the overall success of endodontic retreatment.[19]

CONCLUSION

Group II showed better cleaning efficiency in the coronal and apical thirds of the root canal, while Group I performed better in the middle third. Group III demonstrated the least cleaning efficiency at all evaluated levels. Although all three retreatment systems were effective in removing a considerable amount of gutta-percha and bioceramic sealer, remnants of the filling material were still present on the canal walls. These findings suggest that the use of adjunctive techniques, such as ultrasonic activation, may help improve the removal of residual obturation material and enhance the effectiveness of nonsurgical endodontic retreatment.

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