IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 24, Issue 7 Ser. 6 (July. 2025), PP 47-54
www.iosrjournals.org

Comparative Evaluation Of Retreatability Of A Bioceramic Sealer, MTA-Based Sealer And An Epoxy Resin Sealer Using Two Different Retreatment Files: An In-Vitro Study

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Abstract

Background and Objective:
This in vitro study aimed to evaluate the retreatability of three root canal sealers—Bio-C Sealer (bioceramic), MTA-Ceraseal (MTA-based), and AH Plus (epoxy resin-based)—using two different file systems: ProTaper Universal Retreatment (PTUR) and WaveOne Primary files. The retreatability was assessed based on the area of remaining root canal filling material (APRFM) in straight root canals.

Methods:
*A total of sixty mandibular premolars with single root canals were prepared till size F3 and obturated using AH Plus sealer (**Group 1**); Bio-C sealer (**Group 2**) and Ceraseal (**Group 3**). They were then retreated using PTUR files (**Subgroup A**) and WaveOne Primary file (**Subgroup B**). Pre- and post-retreatment CBCT scans were taken to evaluate residual filling material in the coronal, middle, and apical thirds. Statistical analysis was conducted using appropriate tests.*

Results:
No significant difference was observed between the two file systems. Among the sealers, Bio-C showed the most residual material, followed by MTA-Ceraseal, with AH Plus showing the least. The apical third consistently retained the most filling material.

Conclusion:
None of the groups achieved complete material removal. Bioceramic sealers, despite their advantages, present greater retreatment challenges.

Keywords: *Retreatment, PTUR, WaveOne, Bioceramic Sealer, MTA Ceraseal, AH Plus, CBCT*

Date of Submission: 11-07-2025 Date of Acceptance: 21-07-2025

I. Introduction

The cornerstone of endodontic therapy is the Endodontic Triad—comprising biomechanical preparation, microbial management, and complete obturation of the canal system—which ensures thorough debridement and is essential for long-term treatment success [1,2].

Despite adherence to endodontic principles, 15% to 22% of treatments may fail [3], primarily due to persistent secondary intra-radicular infections [4] resulting from inadequate chemo-mechanical preparation, insufficient obturation, missed canals, or coronal and periodontal leakage [5].

- The most effective approach to manage post-treatment endodontic failure is nonsurgical root canal retreatment, which involves removing the existing obturation material to allow thorough biomechanical cleaning and placement of a biocompatible filling that promotes periradicular healing [6]. Complete removal

of the previous filling is essential, as it can act as a mechanical barrier, preventing disinfectants from reaching bacteria in complex areas such as dentinal tubules and isthmuses [7].

Various combinations of paste, semisolid, and solid materials—with or without sealers—have been explored for root canal obturation. However, gutta-percha has remained the preferred material for over 140 years due to its favorable properties, including compressibility, dimensional stability, biocompatibility, radiopacity, and ease of removal [8]. The most common obturation method combines gutta-percha with a sealer, which fills voids, penetrates lateral canals, and compensates for gutta-percha's poor adhesion to canal walls by bonding it to dentin [9].

A wide range of endodontic sealers is currently in use, with bioceramic sealers like Bio-C Sealer gaining popularity due to their ease of handling, effective sealing ability, biocompatibility, and high pH, which contribute to treatment success. However, limited data exist on their retreatability [10]. In contrast, AH Plus, an epoxy resin-based sealer, is considered the gold standard, backed by extensive clinical evidence [11–14]. MTA-based sealers such as Maarc Ceraseal are also available and have demonstrated biocompatibility, bio-mineralization potential, and improved sealing properties [15].

An essential characteristic of an ideal root canal filling material is its ease of removal during retreatment. Various techniques—including manual files, NiTi rotary instruments, heat devices, solvents, ultrasonics, lasers, and engine-driven tools—have been developed for this purpose. The introduction of specialized rotary retreatment systems has significantly simplified the process. The ProTaper Universal Retreatment (PTUR) system includes three files (D1–D3) with varying tapers and functions: D1 (30/0.09) has a cutting tip for coronal penetration, while D2 (25/0.08) and D3 (20/0.07) remove material from the mid and apical thirds, respectively, using non-cutting tips [16]. WaveOne, a popular reciprocating system, is available in small (20.06), primary (25.08), and large (40.08) sizes, as also demonstrated effectiveness in retreatment procedures.[17–18].

This study aimed to evaluate the retreatability of three endodontic sealers—AH Plus, Bio-C Sealer, and Ceraseal—using two file systems, PTUR and WaveOne. The first null hypothesis stated no significant difference in the retrievability of the three sealers. The second null hypothesis posited no significant difference between the retreatment file systems.

II. Methodology

Access cavities were prepared using an Endo Access bur (Dentsply), and working length was determined radiographically, 1 mm short of the canal length using a #10 K-file. Biomechanical preparation was done using ProTaper Universal Rotary Files up to size F3, with 3% NaOCl irrigation between files.

The canals were dried and divided into three groups (n = 20 each) based on the sealer used:

- Group I: AH Plus
- Group II: MTA Ceraseal
- Group III: Bio-C Sealer

Obturation was performed with gutta-percha and the respective sealers. Samples were mounted on wax blocks, scanned using CBCT, and stored for 2 months prior to retreatment.

Each group was subdivided (n = 10) based on the retreatment file used:

- Subgroup A: ProTaper Universal Retreatment (PTR) files used in a crown-down manner at 500 rpm
- Subgroup B: WaveOne Primary file used in reciprocating motion with minimal apical pressure

Retreatment was considered complete when instruments reached working length without visible debris. A final CBCT scan was performed to assess remaining filling material**.**

The following equation was used to determine the percentage of filling material still present on the canal walls

$$\text{APRFM}^* = \frac{\text{area of remaining filling material}}{\text{area of canal wall}} \times 100$$

The amount of filling material left in the **coronal, middle, and apical** sections of each canal was evaluated according to the following criteria:

No/Slight preference - 0-25% debris on the dentinal surface
Mild presence - 25-50% debris on the dentinal surface
Moderate presence -50-75% debris on the dentinal surface
Heavy presence - >75% debris on the dentinal surface
The debris was not distinguished between filling material and sealer remnants.

Statistical Analysis

One-way ANOVA Test followed by Tukey's post hoc test / Kruskal Wallis Test followed by Dunn's post hoc test [Based on Data distribution] was used to compare the mean percentage of Remaining sealer and gutta percha content between 03 sealers based on type of file used.

Independent Student t Test / Mann Whitney Test [Based on Data distribution] was used to compare the mean percentage of Remaining sealer and gutta percha content between 2 files in each sealer group.

III. Results

The Bioceramic sealer showed the highest residual material across all regions, indicating greater difficulty in removal, while AH Plus was the easiest to retrieve, with MTA sealer showing intermediate retention. Both ProTaper and WaveOne files performed similarly, though WaveOne showed slightly lower residuals overall. Residual material was consistently highest in the apical third across all sealers

Across all analyses, regional variation played a key role. Residual percentages were typically higher in the apical regions for all sealers, followed by the middle and coronal regions. This trend highlighted the difficulty of achieving thorough sealer removal in deeper areas, where mechanical access is more restricted.

Table no. 1 Comparison of mean % of Residual Sealer material b/w 2 Re-treatment files for Bio-C sealer in diff. regions as seen in Coronal & Sagittal sections using Independent Student t Test

Sealer	Region	Files	N	Mean	SD	Mean Diff	p-value
Coronal	Coronal	ProTaper	10	24.80	3.21	0.59	0.69
		Waveone	10	24.21	3.22		
	Middle	ProTaper	10	30.04	3.10	0.60	0.68
		Waveone	10	29.44	3.35		
	Apical	ProTaper	10	35.15	3.18	0.41	0.78
		Waveone	10	34.74	3.26		
Sagittal	Coronal	ProTaper	10	23.85	3.05	0.64	0.65
		Waveone	10	23.21	3.22		
	Middle	ProTaper	10	28.78	3.05	0.72	0.62
		Waveone	10	28.06	3.38		
	Apical	ProTaper	10	33.98	3.12	0.75	0.61
		Waveone	10	33.23	3.25		

Table no. 2 Comparison of mean % of Residual Sealer material b/w 2 Re-treatment files for MTA Ceraseal sealer in diff. regions as seen in Coronal & Sagittal sections using Independent Student t Test

Sealer	Region	Files	N	Mean	SD	Mean Diff	p-value
Coronal	Coronal	ProTaper	10	13.81	2.98	0.45	0.74
		Waveone	10	13.36	2.94		
	Middle	ProTaper	10	19.11	2.91	0.53	0.71
		Waveone	10	18.58	3.25		
	Apical	ProTaper	10	23.97	3.06	0.84	0.55
		Waveone	10	23.13	3.13		
Sagittal	Coronal	ProTaper	10	13.21	2.88	0.85	0.52
		Waveone	10	12.36	2.94		
	Middle	ProTaper	10	18.43	2.81	1.25	0.37
		Waveone	10	17.18	3.25		
	Apical	ProTaper	10	22.75	2.92	0.33	0.81
		Waveone	10	22.42	3.15		

Table no. 3 Comparison of mean % of Residual Sealer material b/w 2 Re-treatment files for AH Plus sealer in diff. regions as seen in Coronal & Sagittal sections using Independent Student t Test

Sealer	Region	Files	N	Mean	SD	Mean Diff	p-value
Coronal	Coronal	ProTaper	10	7.60	2.04	0.28	0.7
		Waveone	10	7.32	0.89		
	Middle	ProTaper	10	12.82	2.17	0.07	0.94
		Waveone	10	12.75	1.84		
	Apical	ProTaper	10	17.75	2.22	0.70	0.38
		Waveone	10	17.05	1.08		
Sagittal	Coronal	ProTaper	10	7.27	1.85	0.35	0.66
		Waveone	10	6.92	1.65		
	Middle	ProTaper	10	12.56	2.11	0.81	0.37
		Waveone	10	11.75	1.84		
	Apical	ProTaper	10	17.38	2.20	0.78	0.41
		Waveone	10	16.60	1.93		

IV. Discussion

Endodontic retreatment aims to thoroughly remove previous root canal fillings to permit disinfection and re-obturation. However, achieving complete removal of root filling materials remains a challenge, as supported by both literature and the findings of this study

Effect of Sealer Type on Retrievability

Statistically significant differences were found in the amount of residual material among the three sealers. Bioceramic sealers retained the most, followed by MTA, with AH Plus being the most retrievable. This trend highlights how chemical composition and bonding mechanisms impact sealer removal.

- **AH Plus**, an epoxy resin-based sealer, is widely used due to its dimensional stability and adhesion. While it demonstrates good dentinal bonding, it remains more retrievable than calcium silicate-based sealers. [19,20]
- **Bioceramic sealers** showed the greatest resistance to removal. Their deep dentinal penetration and chemical bonding through hydroxyapatite formation create a mineralized interface that is difficult to disrupt. [22,21] The mineralized interface and intratubular infiltration hinder the action of mechanical instruments and solvents typically employed during obturation material removal [23]. Studies have consistently demonstrated that bioceramic-based sealers tend to leave higher amounts of residual material within the root canal system compared to epoxy resin-based sealers, particularly in the apical third where mechanical access is more restricted [24,25].
- **MTA-based sealers** also presented removal challenges due to similar hydration and bonding mechanisms, though to a lesser extent than bioceramics. Upon exposure to moisture, calcium silicate particles react with water to form calcium silicate hydrate (C-S-H) gel and calcium hydroxide. The latter further interacts with phosphate ions from body fluids to form apatite-like crystalline structures, which precipitate along the sealer-dentin interface [26]. This results in the formation of a "mineral infiltration zone" characterized by micromechanical interlocking and bioactive bonding with the dentinal tubules, significantly enhancing sealing properties [27]. The chemical bonding to dentin and formation of apatite structures render the material mechanically resistant to removal [28].

These findings align with prior studies that confirm calcium silicate sealers, while clinically beneficial for initial treatment, pose difficulties during retreatment.

File System Performance

No statistically significant difference was observed between ProTaper and WaveOne systems. Both demonstrated similar efficacy across sealer types and canal levels.

- **ProTaper** uses a multi-file rotary system composed of three files (D1–D3) designed for specific canal thirds, combines aggressive cutting action with frictional heat, aiding gutta-percha plasticization and coronal displacement [29]
- **WaveOne**, a single-file reciprocating system designed with high taper, enhancing engagement with filling material while minimizing torsional stress, offers enhanced safety and reduced operator fatigue. [30,31]

Although WaveOne showed slightly lower residual values, both systems were comparably effective overall. Instrument selection may therefore depend more on clinical preference and case-specific anatomy than on performance differences.

Canal Level Differences

Residual material was highest in the apical third across all sealers and file systems. This reflects known challenges in apical instrumentation: narrow anatomy, reduced file reach, and decreased instrument-to-wall contact. The coronal third had the least residual material, likely due to better accessibility and enhanced frictional cleaning. These results highlight the continued need for apical-specific retreatment strategies.[32]

V. Conclusion

While bioceramic and MTA sealers improve primary treatment outcomes, their strong dentinal bonds hinder retreatment. Neither file system achieved complete sealer removal, especially in the apical region, underscoring the limitations of current techniques.

Clinicians should consider both sealer properties and retreatability when selecting materials. Future work should aim to develop sealers with optimal balance between performance and retrievability and explore adjunctive methods (e.g., ultrasonics, solvents) to enhance removal.

Financial support and sponsorship Nil
Conflicts of interest There are no conflicts of interest

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Photos

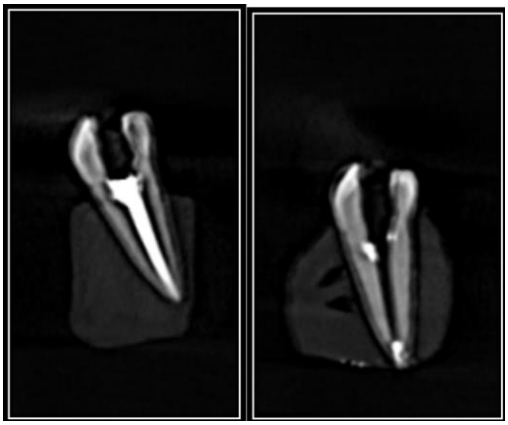

Fig 1: Group 1a: Ah Plus Sealer With Ptur Files
A.) Post Obturation
B.) Post Retreatment

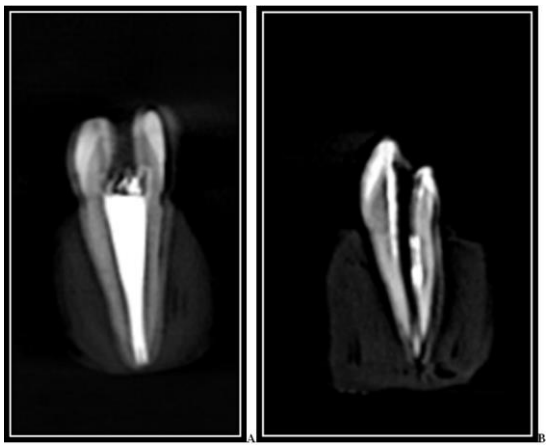

Fig 2: Group 1b: Ah Plus Sealer Waveone Primary File
A) Post Obturation Scan
B) Post Retreatment Scan

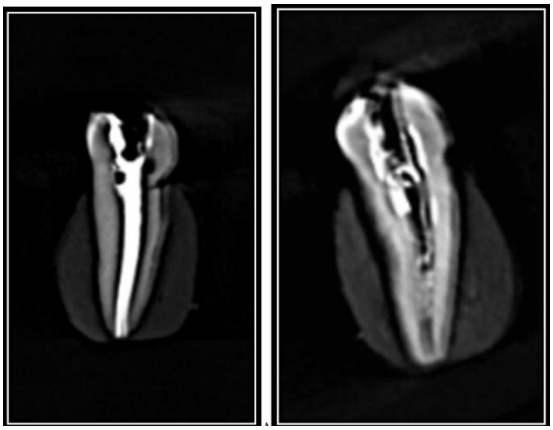

Fig 3: Group 2a: Mta Sealer With Ptur File
A) Post Obturation Scan
B) Post Retreatment Scan

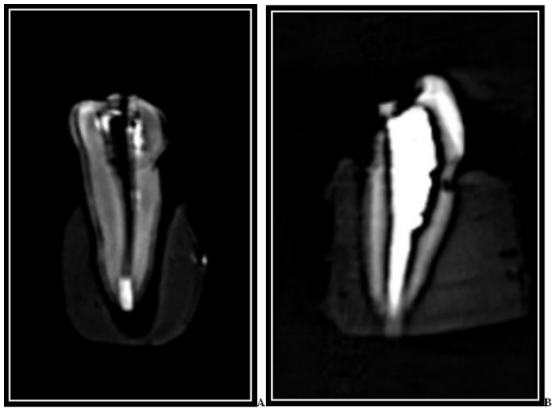

Fig 4: Group 2b: Mta Sealer With Waveone Primary File
A) Post Obturation Scan
B) Post Retreatment Scan

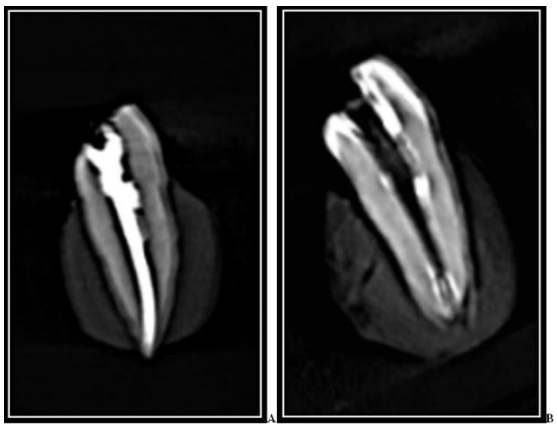

Fig 5: Group 3a: Bio-C Sealer With Ptur File
A) Post Obturation Scan
B) Post Retreatment Scan