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RETRIEVABILITY OF BIO-CERAMIC SEALERS FROM ROOT CANALS OBUTURATED USING TWO DIFFERENT TECHNIQUES

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ABSTRACT

AIM: The aim of this study was to evaluate the remaining filling material percentage after retrievability of bio-ceramic sealers (Well-Root St and endo-sequence BC sealer) from root canals obturated using either single cone or cold lateral condensation techniques.

Methods: Forty-two extracted sound human single-rooted lower premolars were selected and decoronated. Roots were divided into three equal groups (n=14 per group) according to the sealer used. Group A: well-Root St (Vericom, Gangwon-do, Korea) and Group B: endo-sequence BC sealer (Brasseler, Savannah, GA, USA) and Group C: epoxy resin-based sealer AH Plus (Dentsply, Konstanz, Germany). Each group was subdivided into two subgroups according to the obturation technique. Subgroup (1): single cone technique and subgroup (2): cold lateral compaction. Following root canal instrumentation and obturation of all samples, filling material was retrieved. Retrievability was evaluated in terms of the percentage of remaining obturation material using stereomicroscope. Data were analyzed using one-way ANOVA followed by Tukey's post hoc test.

Results: All sealers (Well-Root ST, Endo-sequence BC, and AH-Plus) left more remaining filling material apically, followed by the middle portion and coronal portion, with statistically significant differences between them. Single-coned bio-ceramic sealers (Endo-sequence BC sealer and Well Root ST) exhibited higher residues than resin sealer (AH-Plus) significantly upon the apical portion.

Conclusions: Removing filling material from teeth filled using the single cone obturation technique with bio-ceramic sealers can pose challenges and might need additional methods to assist in the removal process.

KEYWORDS: calcium-silicate, bio-ceramic, remaining filling material, retrievability, resin sealer, Well-root ST, Endo-sequence BC sealer, single cone technique.

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INTRODUCTION

Endodontic failures can occasionally occur for a variety of reasons, which can be frustrating for both the dentist and the patient. As a result, retreatment is used, which may involve prolonged treatment times or occasionally more visits. In a study by Ingle et al., it was revealed that incomplete filling of the root canal space contributed to 58% of root canal treatment failures. [1]

The standard root canal filling typically involves a combination of sealer cement and a central core material, which has predominantly been Gutta Percha. The core functions as a piston on the flowable sealer, helping it spread to fill voids and adhere to the instrumented dentin wall. By design, the sealer primarily contacts the root canal and pulp stump, while the Gutta Percha rarely protrudes from the sealer to touch the dentin or periodontal tissues. Consequently, the sealer must possess essential properties such as biocompatibility and sealing ability. Recent advances in root canal obturation materials have addressed the inadequacies of traditional fillings like gutta-percha and various sealers, which have been shown to allow microleakage and bacterial infection. New materials like Resilon, EndoREZ, Activ GP, Smartseal, and RealSeal provide improved adhesion and sealing capabilities. Resilon eliminates gaps by polymerizing with the sealer, EndoREZ's hydrophilic properties enable deep penetration into dentinal tubules, and Activ GP forms a monoblock that chemically and micromechanically bonds with the canal walls. Smartseal, utilizing polymer technology, expands hydrophilically to fill voids, and RealSeal's synthetic polyester composition offers superior sealing and root strengthening due to its continuous bond formation. These innovations ensure better adhesion to dentine and reduced microleakage, enhancing the effectiveness and durability of root canal treatments.[2]

Bioceramics represent the latest innovation in endodontics. These materials consist of ceramic or metal oxides known for their exceptional biocompatibility, antibacterial, antifungal properties, and superior sealing capabilities. These materials are used in various dental applications, including filling bony defects, root repair, apical filling, sealing perforations, as endodontic sealers, and in regenerative procedures. The main types of bioceramics include alumina, zirconia, bioactive glass, glass ceramics, hydroxyapatite, and calcium phosphates.

Bio-ceramic root canal sealers are categorized chemically into mineral trioxide aggregate (MTA)-based sealers (such as Endo-CPM-Sealers, MTA Angelus, MTA Obtura, ProRoot Endo Sealer, and MTA Fillapex), calcium silicate-based sealers (such as EndoSequence BC Sealer, iRoot SP, and iRoot BP), phosphate-based bioceramic sealers (such as bio-aggregate), and calcium phosphate-based sealers (such as Sankin Apetite and Capseal).[3]

The concept shift from employing endodontic sealers primarily to seal the root canal as a barrier against regrowth or reinfection as known from epoxy resin sealers as the current gold standard to a more biological concept is made obvious when considering the in vitro results. CSBS (calcium silicate-based sealers) can give a bioactive surface with stimulation of the creation of hard tissue, good antibacterial capabilities, and perform well in clinical investigations that have not yet been published in addition to their sealing abilities. The slight solubility of these substances even after setting is what gives CSBS its bioactive potential. The creation of bioactive surfaces on CSBS is made possible by the leaching of calcium hydroxide and the alkalizing potential, which have antibacterial and anti-inflammatory actions and promote apical healing. Solubility of CSBS appears to be a requirement for the beneficial biological properties of these sealers, but on the other hand, the sealer's solubility compromises the effectiveness of sealing a root canal against the regrowth of bacteria and reinfection.(4)

The primary objective during the revision of root canal therapy is to eradicate microorganisms and their by-products, which sustain periapical pathosis. The remaining obturating materials serve as a mechanical barrier between intracanal disinfectants and microbes residing in hard-to-access areas such as dentinal tubules, lateral canals, and isthmus. Therefore, the removal of all filling remnants is necessary to allow irrigants and medicaments to reach every part of the root canal system. Additionally, the apical retrieval of obturating materials during re-instrumentation helps the clinician achieve apical patency. Moreover, residual material may negatively impact the adhesion of the new sealer to dentin. Studies have shown that most remnants after retreatment originate from the sealer. Unfortunately, several reports indicate that complete removal of these remnants cannot be achieved with any known retreatment method.(5)

Gutta Percha is the most often utilized obturating substance in endodontic treatment. Therefore, the focus is mainly on different gutta-percha removal techniques during retreatment. Various techniques are employed for the retreatment of root canal therapy, each serving specific purposes. Initially, GP solvents are used to facilitate the dissolution of gutta-percha filling material. Following this, manual instrumentation using K-files or H-files can aid in further dislodging the filling material. Micro debriders or micro-openers may then be employed for precise and controlled removal of debris from the canal space. Rotary instruments, including Gates Glidden drills/peeso reamers, GPX Gutta Percha remover, GPR System, and Ni-Ti rotary instruments, offer efficient and mechanized removal of obturation material. Specialized rotary instruments such as Pro Taper universal retreatment instruments, Mtwo retreatment files, R-Endo retreatment files, and XP Endo retreatment files are designed specifically for retreatment procedures, providing enhanced precision and effectiveness. Heat transfer devices like heat carrier tips and ultrasonic tips may also be utilized to soften and remove filling material. Finally, soft tissue lasers can be employed to ensure precise and minimally invasive access to the root canal system. (6)

However, prior research has shown that it is uncommon to find canal walls that are entirely devoid of debris. What evaluation technique identifies the complete removal of filler material after orthograde retreatment is still unknown. In several retreatment investigations, the absence of gutta-percha or sealer on the files or paper points was the criterion for retreatment completion. Radiographs were analyzed in other investigations. However, none of these can be used to definitively determine that the retreatment was done. More reliable techniques are needed to find residual root canal filling material. The use of a dental operating microscope and stereomicroscope can greatly enhance the detection of residual gutta-percha after retreatment. These microscopes offer high magnification and illumination that allow for better visualization of the treated area and can help identify any remaining material. (7)

Therefore, the retrievability of the Well-Root ST bio-ceramic sealer is of great interest. However, its retrievability remains questionable.

MATERIALS AND METHODS

TABLE (1) Lists of sealers used:

Materials	Description, Composition, and Manufacturer
1-Well-Root ST	-Pre-mixed bio-ceramic sealer. -Calcium aluminosilicate compound, Zirconium oxide, filler, thickening agent. -Vericom (Gangwon-do, Korea)
2-Endo-Sequence BC	-Premixed injectable root canal sealer utilizing bio-ceramic nanotechnology. -Calcium silicates, Calcium phosphate monobasic, zirconium oxide, tantalum oxide, and thickening agents. -Brasseler (Savannah, GA, USA)
3-AH-Plus	-Two-component epoxy resin-based sealer formula. -Zirconium Dioxide, tricalcium silicate, dimethyl sulfoxide, lithium carbonate, and thickening agents. - Maillefer (Dentsply, Konstanz, Germany)

A. Sample selection:

Forty-two intact human single-rooted single-canaled lower second premolar teeth were gathered from the surgery clinic of the Faculty of Dentistry, Ain Shams University, with the approval of the ethics committee (FDASU-RecEM012129). These teeth were selected based on specific criteria to ensure their suitability for the study. Teeth exhibiting severe attrition, root caries, immature root development, external root resorption, or cracks upon magnified inspection were excluded from the sample. Additionally, radiographic assessment was performed to include only teeth with patent, single, and straight root canals, featuring curvatures ranging from 0° to 5°, and showing no signs of internal resorption, calcification, or prior endodontic treatment.

B. Sample preparation

1- Sample instrumentation:

Forty-two teeth were cleaned with running water, freed of any debris that may have been attached, autoclaved, and kept in saline solution at room temperature until needed. The length of the teeth was standardized to 16 mm for all samples and decoronated using a low-speed diamond disc and water coolant. A size #10 K-file was inserted into the root canal after gaining access to determine the working length. Once it was visible at the apical foramen, patency was confirmed. The working length (WL) was set to be 1 mm shorter.

Protaper Universal files were used to prepare all the roots, and the torque setting, and speed were chosen following the manufacturer's recommendations. According to the operating procedure, the SX file was used to the coronal third of the working length (5 mm) for coronal flaring, the S1 file (D0=.17) was used to the full working length (15 mm), and the S2 file (D0=.20) was used to the full working length.

Using F1 files (#20/7%), F2 files (#25/8%), F3 files (#30/9%), and F4 files (#40/6%), apical was carried out. The canals were irrigated with 2 ml of 5.25% sodium hypochlorite (NaOCl) using a 27-gauge needle and a plastic syringe after each change of files. Apical patency was checked using a size #10 K-file to avoid any abrupt closure of the apical portion. Following the completion of the instrumentation of the canals, each canal was flushed once more with 2 ml of 5.25% NaOCl after being soaked for 1 minute in 1 ml of 17% ethylene-diamine-tetra-acetic acid (EDTA) solution to remove the smear layer. For every root canal, a final saline flush was performed.

2- Sample obturation:

According to each type of sealer in each group, obturation was performed as followed:

Subgroup 1 Single Cone.

Subgroup 2 Cold Lateral Condensation.

3- Removal of core material procedure:

The manufacturer's instructions were followed on removing root canal obturation materials with Pro-Taper Universal retreatment instruments powered by a Wismy endodontic motor at 2 N/cm torque and 500 rpm speed. A small stainless steel hand file #30 was used to create a pilot hole. D1, D2, and D3 were used in a crown-down direction with a brushing action against the canal walls until the working length was reached. The obturation material from the coronal third was removed by gently pressing the D1 file (#30, 9%), which had an active tip to aid initial penetration, into the canal. After that, the middle third's obturation material was gradually removed using the D2 file (#25, 8%). Finally, obturation material from the apical third was removed using the D3 file (#20, 7%). The final apical finishing was carried out using F3 and F4 files followed by final apical refinement using manual file size #45.

4. Evaluation of the remaining obturation material:

The samples were split longitudinally into mesial and distal halves using a chisel after being grooved buccolingually with a diamond disc until the canal's shadow could be seen through a thin layer of dentin. A Stereomicroscope was used to scan the half of the roots that had the most remaining obturation material, which was then analyzed at the coronal, middle, and apical portions using a fixed magnification of 50X.

A Leica digital camera mounted on the stereo microscope was used to take pictures, which were then downloaded to the desktop and saved in JPEG format. The obtained images were analyzed using ImageJ software by calculating the percentage of the area still covered by obturation materials.

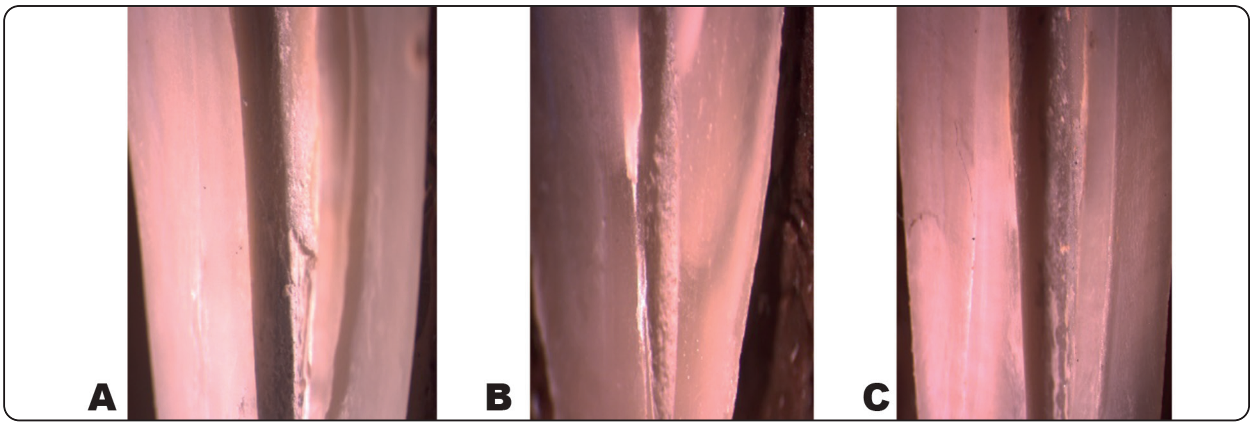

Fig. (1) Stereomicroscopic images showing remaining filling materials between different techniques on the middle third. (a)well-Root ST (b) Endo-sequence BC sealer (c)AH-Plus.

C. Results:

Percentage of remaining filling material (Technique Effect):

In the apical third, for the AH-Plus group; there was a non-significant difference between single cone and cold lateral (P = 0.0577). while in both the BC sealer group and well-root ST sealer group; there were statistically significant differences between single cone and cold lateral with (P=0.0162) and (P=0.0001) respectively.

In the middle third, for the AH-Plus group; there was a non-significant difference between single cone and cold lateral (P=0.1674), while in both the BC sealer group and the well-root ST sealer group; there were statistically significant differences between single cone and cold lateral (P=0.0008) and (P < 0.0001) respectively. The well-root ST sealer again exhibited significantly higher remaining material residues compared to the other two sealers.

In the coronal third, for AH-Plus sealer; there was a non-significant difference between single cone and cold lateral (P=0.2871), while in both the BC sealer group and the well-root ST sealer group; there were statistically significant differences between single cone and cold lateral (P<0.0001) and (P=0.0007) respectively. Once again, the Well-root ST sealer demonstrated significantly higher residuals than the other two sealers.

Overall, the analysis revealed that the well-root ST sealer consistently showed significantly higher mean percentages (%) of remaining materials on the dentine interface compared to the other two sealers in the single cone and cold lateral compaction techniques in all three root thirds. This finding suggests that the well-root ST sealer left the highest residues making it not a superior option for achieving better retrievability during root canal treatment.

TABLE (2) Percentage of remaining filling material percentage among root canal thirds on apical, middle, and coronal thirds:

		Group A (Well Root ST)		**Group B (BC Sealer)**		**Group C (AH Plus)**	
		M	**SD**	**M**	**SD**	**M**	**SD**
Apical Third	**Single**	42.20^{a}	3.81	38.53^{a}	3.32	19.90^{b}	3.92
	Cold lateral	35.40^{c}	2.28	34.80^{c}	2.96	17.11^{b}	1.89
	P value (Independent t-test)	**<0.0001***		**0.0162***		**0.0577(NS)**	
Middle Third	**Single**	28.33^{a}	2.58	25.42^{a}	2.96	14.58^{b}	2.88
	Cold lateral	21.83^{c}	1.84	21.09^{c}	1.72	14.04^{b}	1.73
	P value (Independent t-test)	**<0.0001***		**0.0008***		**0.6174(NS)**	
Coronal Third	**Single**	18.87^{a}	2.34	19.20^{a}	2.66	10.38^{b}	2.02
	Cold lateral	13.75^{c}	3.17	13.11^{c}	2.08	9.63^{b}	0.77
	P value (Independent t-test)	**0.0007***		**<0.0001***		**0.2871(NS)**	

M; Mean, SD; Standard Deviation, P; Probability Level
Means with different superscript letter in the same row were significant different Tukey's post hoc test
****; Significant Difference*** ***NS; Insignificant Difference***

TABLE (3) Percentage of remaining filling material percentage between different techniques (single cone and cold lateral compaction):

		Group A (Well Root ST)		Group B (BC Sealer)		Group C (AH Plus)		P value
		M	SD	M	SD	M	SD	
Apical Third	**Single**	42.20[a]	3.81	38.53[a]	3.32	19.90[b]	3.92	**<0.0001***
	Cold lateral	35.40[c]	2.28	34.80[c]	2.96	17.11[b]	1.89	**<0.0001***
Middle Third	**Single**	28.33[a]	2.58	25.42[a]	2.96	14.58[b]	2.88	**<0.0001***
	Cold lateral	21.83[c]	1.84	21.09[c]	1.72	14.04[b]	1.73	**<0.0001***
Coronal Third	**Single**	18.87[a]	2.34	19.20[a]	2.66	10.38[b]	2.02	**<0.0001***
	Cold lateral	13.75[c]	3.17	13.11[c]	2.08	9.63[b]	0.77	**0.0006***

M; Mean, SD; Standard Deviation, P; Probability Level
Means with different superscript letter in the same row were significant different Tukey's post hoc test
****; Significant Difference*** ***NS; Insignificant Difference***

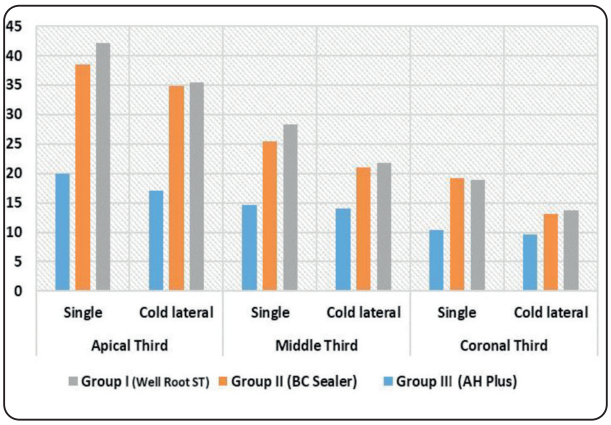

Fig. (2) Bar chart revealing mean percentages of remaining filling materials between different techniques on apical, middle, and coronal third.

DISCUSSION

The removal of obturation material during non-surgical retreatment was laborious, time-consuming, and exhausting for both the patient and the practitioner. Therefore, it was advised to use rotary Ni-Ti instruments when performing root canal retreatment. The teeth underwent de-coronation, and the working length was standardized. While this method doesn't precisely replicate clinical conditions, it improved the comparability between groups by removing variations caused by different crown lengths and root canal access. Consequently, it enhanced compatibility among the experimental groups.[8,9] .

The retreatment procedure was said to be finished when there was no visible filling material left on the last instrument utilized. However, all the canals still had some remaining obturation material adhered to the canal walls, which aligned with findings from prior research [10,11]. This suggested that the absence of filling material on the instrument does not necessarily indicate complete removal of the obturation material from the canal. In the present study, additional canal instrumentation was performed beyond the last retreatment file (D3), reaching F4, and subsequently using a file size of #45 for apical refinement, as previously recommended by Colaco et al. [12] and Giuliani et al. [13] This additional instrumentation and combination may account for the lower percentage of remaining obturation material compared to earlier studies.

The Protaper universal retreatment rotary system was employed in the current study because it was one of the best retreatment rotary systems for efficiently removing obturation material with the fewest amount of residual material [14–16]. It consisted of three files: D1, D2, and D3 [17–19], the first of which has a working tip that promotes more effective initial penetration in gutta-percha. When filling materials are removed, decrease the probability of non-active tips of D2 and D3 of ledging, perforation, and stripping during gutta-percha removal [18,19].

Gutta-percha was the most frequently used core material for root canal filling. Unfortunately, Gutta-percha should be used in conjunction with a sealer due to its pretty poor sealing abilities. It was now verified that the sealer, by blocking the irregularities between the pulp space and the core filling material, played a crucial role in sealing the canal [20].

Like other retreatment investigations [8,21,14,17], NiTi rotary retreatment files were utilized to obtain cautious and uniform instrumentation with a brief working period. The PTR method was selected to be compatible with other studies [8,13,16,22,21] that used it for standardized retreatment processes. When used without fluid, PTR files (D1, D2, and D3) ejected about 0.4 mg of debris apically, according to Huang et al. [22]. The shape of the ovate channel, which PTR files cannot readily reach, may be responsible for the residual filling material[21]. By using manual or mechanical files, additional apical expansion may reduce the apical sealant residue [23].

Upon comparison of patency regaining between Endo-sequence BC sealer and AH-Plus after re-treatment, Bc sealer showed higher remnants and residues of the material. Residual BCS was observed within the apical canal space and around the apical foramina leading to difficulty in regaining patency and working length. Contrary to AH-Plus patency and working length were regained in 100% of samples. [24]

Oltra et al study demonstrated that the BC Sealer group had significantly more residual filling material than the AH Plus group regardless of whether both sealers were retreated with chloroform or not.[25].

Upon comparison of Well root ST to resin sealer Adseal, the scanning electron microscopy images revealed distinctive characteristics of the dentinal tubules. Adseal exhibited a significant number of clear dentinal tubules, while Well Root showed that the orifices of dentinal tubules were filled by the sealer.

Well-root was a calcium silicate-based material, which formed chemical bonds with dentin through biomineralization upon contact with biological tissues. This property may explain why ADSEAL was easier to remove compared to Well Root and Ceraseal[26].

Upon comparison of the remaining filling material between Well Root St and AH-Plus using the single cone technique and cold lateral technique. It was found that the apical portion showed the highest remaining material among the other two-thirds however the cold lateral technique between those two sealers showed higher residuals in the Well Root ST. On the other hand, in the same sealer Well Root ST showed the highest remaining material in single cone technique when compared to cold lateral technique. [27].

Our results coincided with the studies of Oltra et al [25], Hess et al[24]. Various factors could contribute to the variation in findings across previously conducted studies concerning the percentage of remaining obturation material following retreatment. It was important to note that no system had achieved complete material removal. One such variable was the variation in obturation techniques utilized[28]. Photomicrographic analysis utilizing ImageJ software is somewhat subjective in nature; however, it has been noted to be effective in determining the percentage of remaining obturation material and reducing subjectivity in the scoring method based on a scale.[29]

Enabling a higher proportion of gutta-percha and a lower proportion of bio-ceramic sealer could ease retreatment procedures. This differed from single-cone obturation technique, where the bio-ceramic sealer percentage was greater, resulting in a more significant impact on the retreatment process due to its bio-mineralization capabilities and the subsequent development of strong chemical bonds with root dentin.[30]. Additional factors to consider included variations in the retreatment rotary system utilized, particularly in terms of size and taper [31], using of solvents [25][32]. Alternatively, variations might arise from the use of auxiliary methods to aid rotary files in the retreatment process. [33].

CONCLUSION

Removing filling material from teeth filled using the single cone obturation technique with bioceramic sealers can pose challenges and might need additional methods to assist in the removal process..

RECOMMENDATIONS

1- Use of Solvents: Consider using appropriate solvents such as chloroform or mineral oil to soften the bioceramic sealer before attempting retreatment. This can help facilitate the removal of the sealer from the root canal system.

2- Mechanical Techniques: Employ mechanical techniques such as ultrasonic instrumentation or rotary files designed for retreatment procedures. These instruments can aid in the mechanical disruption and removal of the bioceramic sealer from the root canal walls.

3- Consideration of Alternative Techniques: In cases where traditional retreatment methods are ineffective or challenging, consider alternative techniques such as laser-assisted retreatment or micro-surgical approaches to achieve optimal outcomes.

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