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Chemico-Mechanical Retrieval of Two Bioceramic –Based Obturation Techniques (In-Vitro Study)

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ABSTRACT

Introduction: Single cone technique and bioceramic sealers have been highly anticipated recently in root canal treatment, yet their retreatability is still controversial. ***Aim:*** To assess the cleanliness of the root canal walls after Chemico-mechanical removal of the guttapercha obturated with different techniques, cold lateral condensation, and single cone effect of different obturation techniques with or without solvent. ***Methodology:*** Thirty-two recently extracted human permanent mandibular premolars with a single canal were collected. Samples were randomly distributed among two groups (n=16) based on the obturation technique followed using bioceramic sealers; Cold Lateral Compaction/ceraseal sealer and Single Cone Technique/Ceraseal. Each group was further subdivided into two subgroups according to using of solvent (n=8); then retreatment of samples was done. Retrievability was evaluated in terms of the remaining obturation material percentage using the stereomicroscope and Imagej software. The percentage of opened dentinal tubules inside the canal was evaluated using SEM. ***Results:*** The highest mean percentage of the remaining guttapercha was found in the single without a solvent group while the lateral without solvent group achieved the lowest one. Moreover the lateral condensation without solvent group achieved the highest mean percentage of open dentinal tubules while the single without solvent group achieved the lowest one. ***Conclusion:*** the presence of solvent and bioceramic sealer results in more blockage of dentinal tubules and difficulty to achieve optimum canal cleanliness.

Keywords: Retrievability, Single cone technique, Cold lateral, Bio-ceramics, Solvent.

INTRODUCTION

The aim of endodontic treatment is to have bacterial-free canals with hermetic seals. These can be achieved by the use of mechanical and chemical means. Despite the high success rate, high predictability of endodontic treatment failure may occur.[1] Endodontic retreatment is mainly caused by insufficient cleaning and inefficient obturation.[2] Cohen and Hargreaves also suggested other causes for failure such as

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poor access cavity, missed canal, undiagnosed perio-endo lesions, or inadequate coronal seal, other causes as extraradicular infection, foreign body reaction, or a true cyst.[3] These days, a simple yet successful obturation technique is much needed in order to provide optimal care with minimal stress for both patients and physicians. The use of rotational NiTi instruments and corresponding taper gutta percha cones has led to the widespread adoption of the single cone obturation technique. According to Ingle et al. 58% of root canal treatment failures are related to inadequate filling of the root canal space.[4] Thus, it seemed valuable to assess the retrievability of bioceramic sealers using the single cone obturation approach. Grossman mentioned that the ideal sealer property was to be easily removed from the root canal.[5] Bioceramic sealers provide a tight seal, have a high pH, are biocompatible, and become insoluble after setting. These sealers should not be utilized as root filling materials; instead, they should be used as sealers in combination with a core substance.[6] However, it has been demonstrated that the bio-mineralization activity improves dentin adherence and resistance to dislocation. The previously described characteristic, besides their hardness after setting, may prevent the complete sealer removal from the root canal during the secondary endodontic treatment.[7]

There are several obturation methods that may be used, such as vertical condensation, cold lateral compaction, thermoplastic gutta-percha, and single-cone obturation. The cold lateral compaction approach has demonstrated positive clinical outcomes, a high degree of safety, and cost effectiveness .[8] Its disadvantages include a high degree of complexity, a chance of void development, and a danger of vertical root fracture.[9] The single cone technique involves the preparation of a single gutta-percha point with a taper that complements the canal's form and taper. This point is then placed inside the canal to allow full obturation without the need for any auxiliary points.[9] This method is favored since it is quick and easy to use and doesn't need compaction. The outcome of this approach is more dependent on the qualities of the sealer because it takes a larger volume of sealer than the compaction and condensation processes.[10] In endodontic therapy, solvents are solutions used to soften the root filling material.[11] There are different kinds of solvents on the market, but none of them fully satisfy the criteria of the perfect solvent, which include being nontoxic and noncarcinogenic to surrounding tissues, patients, and clinicians, delivering effective

gutta percha softening, and being viable for a sufficient amount of time and at a reasonable cost.[12] For instance, due to its high volatility, chloroform has long been the preferred solvent; nonetheless, it is the most cytotoxic to periapical tissues.[11]As a result, novel compounds have been investigated,[12,13] but none have demonstrated adequate qualities. The effectiveness of files and solvents in eliminating remaining gutta percha during retreatment, or the quantity of material that remains after employing different files and solvents, has been the subject of several studies.[11,12] It's still unclear, though, which approaches work better and whether solvents are necessary to remove root material completely.

MATERIALS AND METHODS

Sample selection and preparation:

Thirty-two extracted single-rooted mandibular premolars were selected and obtained from the MIU teeth bank. The teeth were selected to have mature apices, with single, straight root canals, with no evidence of resorption. Teeth were assessed radiographically to exclude the presence of calcifications, pulp stones, and internal or external root resorption and to confirm the existence of a single straight canal and full root development. All samples were kept hydrated in a covered container containing saline. They were handled in accordance with all infection prevention and control procedures, sealed in sterilization pouches, and autoclaved at 121 °C at 15 lbs pressure for 20 minutes. Under continuous water cooling and magnifying loupes 2.5X, access cavities were made in all teeth using a contra-angle high-speed handpiece.

Root canal instrumentation:

A k-file size 15 was inserted to confirm patency (MANI, Tochigi, Japan). Working length was calculated by measuring the file length while flushing with the apex and subtracting 1 mm. All canals were instrumented and prepared with Mpro rotary files in the crown down technique, starting with the orifice opener #18/.04 preparing the coronal third, then the yellow file #20/.04 with intermittent strokes, removing debris with gauze, and checking the file before re-inserting it. The last rotary file was the red file #25/.06; both files were used to the full working length. The NSK Endo Mate AT Endo Motor's speed and torque were set according to the manufacturer's specifications, with a speed of 350 RPM and torque of 2.5 Ncm. Further expansion till master apical file size g X7 Edge File rotary file system (EdgeEndo, New Mexico, USA) till size 40/0.06. Irrigation and patency were performed using a manual k-file size #10

between each rotary or manual file to verify that straight-line access from the coronal orifice to the apical foramen was accomplished and that no iatrogenic mistakes. The irrigation used during preparation was 2.25% sodium hypochlorite (NaOCl) with a total volume of 25 ml and a side-vented 30-gauge needle inserted up to 1mm short of the working length. The canals were then dried by paper points, flushed with 2 ml of saline, and dried again by #40 paper points to prevent different irrigant interactions. To remove the smear layer, the canals were irrigated with 3 ml of 17% EDTA solution for one minute, then dried by paper points, followed by a final flush with saline. The canals were dried using paper points size #40.

Samples obturation:

I: Cold lateral condensation group

Obturation in all canals of (group I, 16 samples) was done using gutta-percha master cone size #40 with taper 0.02. Bioceramic sealer was injected into the canal. The master gutta-percha cone was inserted inside the canal and fitted to the working length with a tug back. A spreader size #35 was fitted deeply into the canal three mm short of the working length to insert the auxiliary gutta-percha cones size #30 with taper 0.02. After completing the condensation of all auxiliary cones, a hot condenser was used to remove the excess gutta percha up to the canal orifice, and condensation was done on the cold side of the instrument.

II: Single cone obturation group

Obturation in all canals of (group II, 16 samples) was done using gutta-percha master cone size #25 with taper 0.06 and Metabiomed bioceramic sealer. Bioceramic sealer was injected into the canal. The master gutta-percha cone was placed inside the canal and fitted to the working length with a tug back. After confirming the working length, a hot condenser was used to remove the excess gutta percha up to the canal orifice, and condensation was done on the cold side of the instrument. The teeth were then radiographed to assess the quality of the obturation and the apical extent of the root canal fillings. The quality of obturation was confirmed when no voids could be found on the postoperative radiographs. The samples were stored in an incubator at 37°C and 100% humidity environment for two weeks for the complete setting of the sealer.

Retrieval of root canal filling

A randomization list was made for the groups using an Excel sheet generated by specialized software and concealed to the principal investigator.

In the subgroups (Group I.A and Group

II.A) (n=8 each):

After canal obturation, Mechanical retrieval of gutta percha and sealer by rotary files (protaper retreatment kit) and the solvent was done. A plastic syringe filled with 1 mm of guttapercha solvent then is inserted at the canal orifice, and a few drops were used. Then mechanical retrieval started by D1 file on the coronal third. Then D2 file was used. D3 was finally used to reach full working length. Irrigation of the canals was done using two ml of 2.25% NaOCL with a side-vented 30-gauge needle. Solvent and irrigant (NaOCL) were reapplied several times during the procedure to allow softening of the guttapercha and allow removal of debris, cleaning of the canals, and sliding of the rotary files into the canal with minimal possible errors or complications. The final irrigation with 2.5 ml of 2.6% NaOCL was performed, followed by drying with paper points size #35. Irrigation with 2 mL of saline was followed by drying with paper points size #35.

In the subgroups (Group I.B and Group II.B) (n=8 each):

After canal obturation, Mechanical retrieval of gutta percha and bioceramic sealer by rotary files without solvent (protaper retreatment kit) was done. The same steps as the previous procedure were followed, except that no solvent was added throughout the whole procedure. The retreatment procedure was considered complete when the rotary file reached the full working length and no remaining filling or debris on the rotating file was visible to the naked eye.

Samples evaluation:

By using stainless steel discs, all samples were grooved longitudinally at the mesial and distal surfaces and sectioned mesiodistally. One-half of each sample was examined under the stereomicroscope and Scanning electron microscope. Retreatability was evaluated in terms of the remaining obturation material percentage using the stereomicroscope and Imagej software. The percentage of opened dentinal tubules inside the canal was evaluated using SEM.

Statistical analysis

Values for the mean and standard deviation (SD) were used to show numerical data. They were examined for normalcy using the Shapiro-Wilk test (version 25, IBM Co. USA) and the data distribution. The parametric data (Stereo microscope images) were subjected to one-way ANOVA, and the independent samples were subjected to Tukey's post hoc test. For non-parametric data (SEM images results) was performed by applying Kruskal-Wallis test followed by

Mann-Whitney test. A significant level of $p \leq 0.05$, $p \leq 0.001$ was considered highly statistically significant was set.

RESULTS

The percentage of the remaining gutta-percha:

For the total remanent %: The highest mean of remanent percentage was achieved in the GII.D while the lowest one was achieved in the GI.B **(Table 1 and Figure 1)**.

The overall P-value for intergroup comparison was statistically significant (P-

Table (1): Mean ±SD and inter-group comparison of remnant percentage in different thirds in the four subgroups (ANOVA test).

	Coronal	Middle	Apical	Total remanent %
Single solvent	64.68±31.82^{A}	70.82±29.27^{A}	58.28±23.42^{AB}	65.58±25.35^{A}
Single without solvent	70.69±20.29^{A}	71.46±15.62^{A}	67.39±20.03^{A}	69.43±12.39^{A}
Lateral condensation	65.44±22.1^{A}	65.87±21.21^{A}	41.46±24.24^{B}	59.23±16.52^{AB}
Lateral without solvent	49.52±22.18^{A}	37.12±24.9^{B}	42.19±17.43^{B}	44.62±23.03^{B}
P-value	0.096^{NS}	< 0.001^{HS}	0.021^{S}	0.005^{S}

- S= Significant level (P ≤ 0.05),
- HS= Highly significant (P < 0.001),
- NS= Non-significant. (P>0.05),
-The means with different superscripts in the same column are statistically significant different.

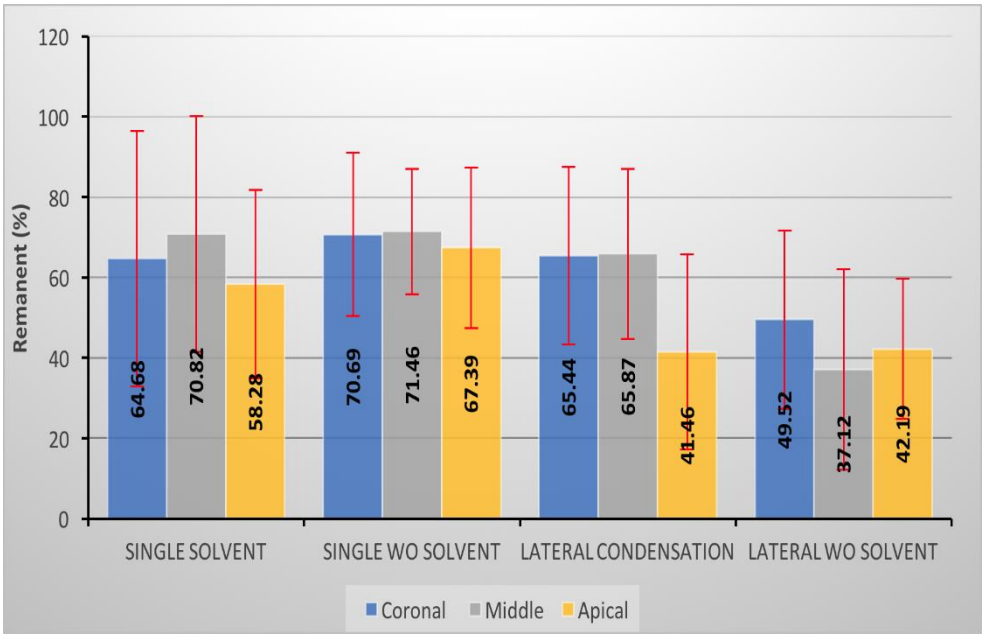

Figure (1): A bar chart representing the mean and SD of remanent percentage in different thirds in the four major groups.

value < 0.05), and this significance is attributed to the difference between the GI.B group and the GII.D group for the percentage of the remaining gutta-percha in different thirds of the canal **(Table 2).**

In the Coronal Third: The lateral without solvent group achieved the highest mean percentage of open dentinal tubules (**Figure 3),** while single group without solvent achieved the lowest one (**Figure 4)**.

Table (2): Mean ±SD and intra-group comparison of remnant percentage in different thirds in the four subgroups (ANOVA test).

	Coronal	Middle	Apical	Total remanent %	P-value
Single solvent	64.68±31.82[a]	70.82±29.27[a]	58.28±23.42[a]	65.58±25.35	0.699[NS]
Single without solvent	70.69±20.29[a]	71.46±15.62[a]	67.39±20.03[a]	69.43±12.39	0.906[NS]
Lateral condensation	65.44±22.1[a]	65.87±21.21[a]	41.46±24.24[b]	59.23±16.52	0.049[S]
Lateral without solvent	49.52±22.18[a]	37.12±24.9[a]	42.19±17.43[a]	44.62±23.03	0.711[NS]

- S= Significant level (P ≤ 0.05),
- NS= Non-significant. (P>0.05),
-The means with different superscripts in the same row are statistically significant different.

The percentage of open dentinal tubules under SEM

Effect of obturation technique (Inter-group comparison): (Table 3 and Figure2)

In the Middle Third: The lateral condensation group achieved the highest mean percentage of open dentinal tubules, while single solvent group achieved the

Table (3): Mean ±SD and inter-group comparison of percentage of open dentinal tubules in different thirds in the four subgroups (Kruskal-Wallis test).

	Coronal	Middle	Apical
Single solvent	0.26±0.07[B]	0.38±0.13[B]	0.08±0.06[B]
Single without solvent	0±0[B]	0.7±0.26[B]	2.08±0.51[A]
Lateral condensation	9.51±4.85[A]	5.94±1.82[A]	3±1.75[A]
Lateral without solvent	11.98±5.1[A]	5.69±2.87[A]	2.66±1.87[A]
P-value	< 0.001[HS]	< 0.001[HS]	0.002[S]

- S= Significant level (P ≤ 0.05),
- NS= Non-significant. (P>0.05),
-The means with different superscripts in the same column are statistically significant different.

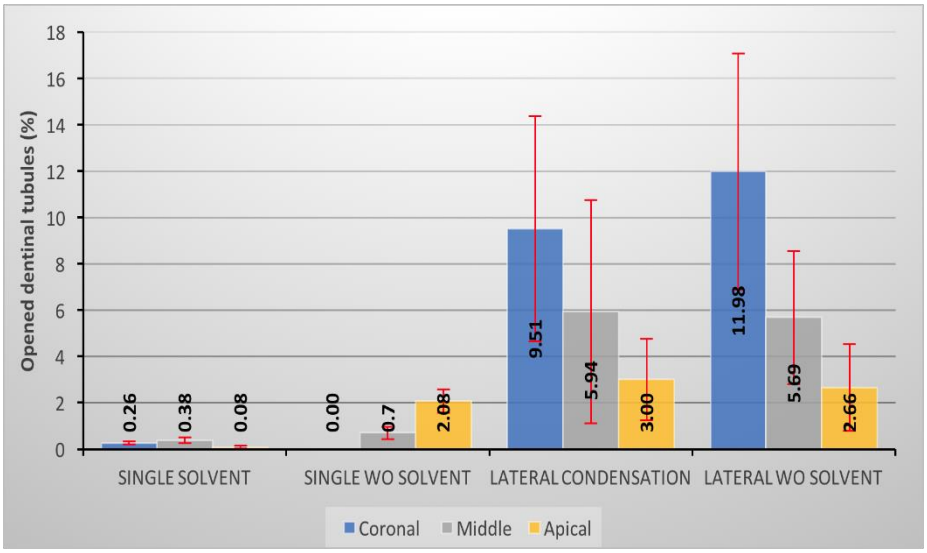

Figure (2): A bar chart representing the mean and SD of percentage of open dentinal tubules in different thirds in the four major groups.

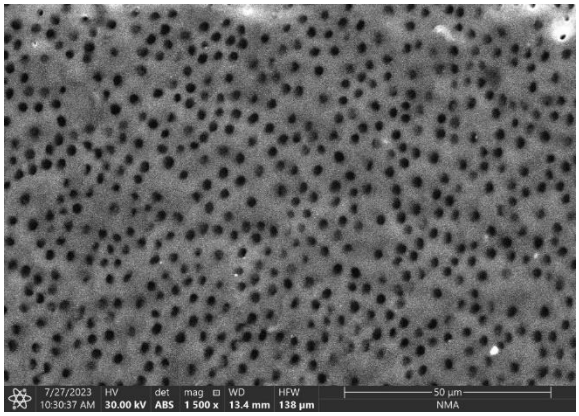

Figure (3): Scanning electron microscopic photo of the coronal third of lateral without solvent group.

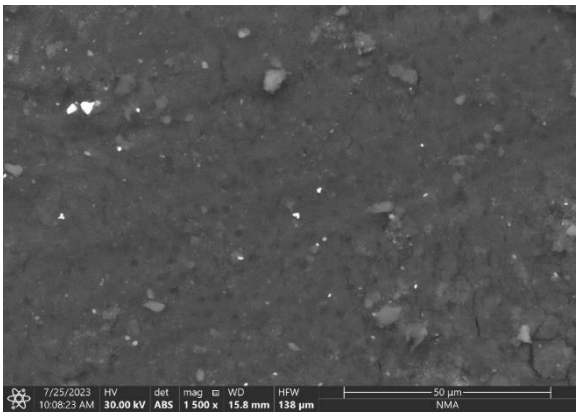

Figure (4): Scanning electron microscopic photo of the coronal third of single without solvent group.

lowest one.

In the Apical Third: The lateral condensation group achieved the highest mean percentage of open dentinal tubules, while single solvent group achieved the lowest one.

Effect of the location of studied thirds (Intra-group comparison): (Table 4)

In the lateral condensation group (GI. A): There was a statistically significant difference in the mean of percentage of open dentinal tubules between the three-thirds; the overall p-value for comparison between the three-thirds was statistically highly significant (P-value = 0.001).

In the lateral without solvent group -

(GI. B): There was a statistically significant difference in the mean percentage of open dentinal tubules between the three thirds. The overall p-value for comparison between the three-thirds was statistically highly significant (P-value < 0.001).

comparison between the three-thirds was statistically significant (P-value < 0.05).

DISCUSSION

The success rate of root canal therapy is about 90%. Before deciding to proceed with surgical intervention or extraction,

Table (4): Mean ±SD and intra-group comparison of percentage of open dentinal tubules in different thirds in the four subgroups (Kruskal-Wallis test).

	Coronal	**Middle**	**Apical**	**P-value**
Single solvent	0.26 ± 0.07^{a}	0.38 ± 0.13^{a}	0.08 ± 0.06^{a}	0.303^{NS}
Single without solvent	0 ± 0^{b}	0.7 ± 0.26^{b}	2.08±0.51a	0.021^{S}
Lateral condensation	9.51 ± 4.85^{a}	5.94 ± 1.82^{b}	3 ± 1.75^{c}	0.001^{HS}
Lateral without solvent	11.98 ± 5.1^{a}	5.69 ± 2.87^{b}	2.66 ± 1.87^{c}	$< 0.001^{HS}$

- S= Significant level (P ≤ 0.05),
- HS= Highly significant (P < 0.001),
- NS= Non-significant. (P>0.05),
-The means with different superscripts in the same row are statistically significant different.

In the Single solvent group (GII.C): There was no statistically significant difference in the mean percentage of open dentinal tubules between the three-thirds. The overall p value for comparison between the three-thirds was not statistically significant (P-value > 0.05).

In the Single WO solvent group (GII.D): There was no statistically significant difference in the mean percentage of open dentinal tubules between the Coronal and Middle thirds, while there was a significant difference between Apical third and other two-thirds. The overall p-value for

unsuccessful endodontic cases must first undergo non-surgical retreatment. It takes the right tools and manipulation to retrieve the root canal obturation materials. Nonsurgical retreatment results in fewer problems and less pain, edema, and discomfort, that's why non-surgical retreatment is preferable.[14] In their review, Good and McCammon enumerated various mechanical, chemical, and thermal instruments, materials, and techniques for removing root canal fillings and came to the conclusion that none of them could clean the canal completely.[12]

Bioceramic sealer is widely used now in

endodontics because of its unique physical and biological features. However, researchers are concerned about their retrieval capabilities.[15] The retreatability of BC sealer is directly related to its ability of the material to penetrate the dentin; the deeper the sealer penetration to dentine the more challenging the retreatment.[5]

For samples retreatment, several previous studies[16,17] found the use of multiple file systems faster with higher efficiency than the single file technique. Dentsply Sirona's Protaper retreatment files allow immediate penetration with minimal apical pressure, making root canal debridement easier.[18] These files are constructed of a specifically formulated NiTi alloy, which has exceptional mechanical strength capabilities, enough flexibility to avoid canal transit, and substantial enough hardness for successful cutting.[19]

The effect of using a solvent in retreatment has been debatable among authors. The solvent is used in several studies[6,16,20] as it facilitates the instrument penetrating the gutta-percha and reduces the excessive cutting in the tooth structure to allow GP removal from the wall. Thus, the removal of gutta-percha is usually done by mechanical means with the aid of organic solvents.

Since it has been considered the gold standard, most used, and investigated technique, cold lateral technique was used to compare single cone technique retreatment efficacy, while warm vertical compaction was excluded because of the effect of heat on the bioceramic sealers.[21]

Based on a review by Spencer et al. that mentioned the advantages of utilizing sodium hypochlorite as antibacterial agent, tissue-dissolving agent, low viscosity, an adequate shelf life, and is readily accessible and affordable.[22] Samples were kept for two weeks before the retreatment procedure to ensure the complete setting of bioceramic sealer. This is in line with Loushine et al. investigation.[23] The roots were longitudinally sectioned and examined using a stereomicroscope and scanning electron microscope to evaluate the remaining filling material.[24] This form of imaging was chosen over radiography technologies since the latter only produces a two-dimensional image and is susceptible to distortion and enlargement.[25] Although photomicrographic analysis utilizing ImageJ software can be subjective, it has been shown to be effective in assessing the percentage of residual obturation material and minimizing subjectivity in the scoring method on a scale. The effect of solvent use was consistent with Hess et al.[26] and Oltra et

al.[27] investigations, which revealed that using a solvent enhanced the effectiveness of gutta-percha and sealer retrieval in general.

Positive results were documented for the use of bioceramic sealer during retreatment that matched Kim et al.'s study, in which full working length was achieved during retreatment, while bioceramic sealer showed deep penetration inside the canal.[28] Furthermore, the authors concluded thatthe type of obturation technique used for initial root canal treatment has influenced the amount of remaining filling material, as mentioned in Athkuri et al. and Aref et al. investigations .[29,30]

In contrast, Martins et al.[31] investigation results stated that after endodontic retreatment, the cold lateral technique encouraged a higher percentage of canals to be penetrated by the sealer than the single cone approach in the apical segment. The result was consistent with Sari and Yalmiz study in which the remaining filling material was observed in all canals, regardless of the root canal sealer or the obturation technique used.[32] Maronga et al.[33] came to the conclusion that although bioceramic sealers may be negotiated with basic anatomy, doing so may take more time. Also, inappropriate bioceramic sealer use greatly reduces the success of retreatment.

The variance in previously published research on the amount of residual obturation material following retreatment might be attributed to a number of factors. It should be observed that the material could not be completely removed by any method. An example of these factors is the variation in obturation methods,[29] cold lateral technique permits a higher proportion of gutta-percha and a lower proportion of bio-ceramic sealer, hence facilitating retreatment. In contrast to Single Cone Technique, when a larger percentage of bio-ceramic sealer is used, its impact on the retreatment process is more noticeable due to its ability to bio-mineralize and the resulting development of a strong chemical bond with the root dentin.[34] Additional variables include the use of solvents and variations in the retreatment rotary system in terms of size and taper.[27]

CONCLUSION

Within the restrictions of this study, it can be reported that filling material from teeth that have been obturated implementing a single cone obturation technique and bio-ceramic sealer is difficult to retrieve and may need additional procedures to facilitate the retrieval process.

CONFLICT OF INTEREST

No conflict of interest.

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