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Is Apical Enlargement with Single Reciprocating Instruments the Key to Success in Endodontic Retreatment?

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Abstract **Original Research Article**

Modern endodontics has provided significant advancements, particularly in the treatment and retreatment of root canals. However, the complete removal of obturation material during retreatment remains a challenge, especially in the apical third of root canals, where complex anatomy imposes limitations. This study aimed to evaluate the effectiveness of using WaveOne Gold reciprocating instruments of different diameters and kinematics (brushing motion and pecking motion) for removing obturation material from root canals during retreatment, with a particular focus on the apical third. Thirty human maxillary molars with separate roots were selected and divided into four groups. Root canals were prepared and obturated using different WaveOne Gold instruments (Primary and Medium) and then retreated with larger diameter instruments using different kinematics. The removal of obturation material was evaluated through cone beam computed tomography (CBCT). The results were statistically analyzed using ANOVA and logistic regression. Statistical analysis revealed no significant differences between the groups regarding the type of instrument or kinematics applied. Residual obturation material was observed in approximately 60% of the samples, regardless of instrument diameter or kinematics used, indicating that complete removal of obturation material from the apical portion of root canals remains a substantial challenge. The use of larger diameter instruments, such as the WaveOne Gold Medium, and the application of brushing motion kinematics did not prove significantly more effective in removing obturation material compared to smaller diameter instruments. These findings highlight the need to explore new approaches and technologies to optimize obturation material removal, especially in complex anatomical regions like the apical third of root canals.

Keywords: Apical Enlargement, Endodontic Retreatment, Obturation Removal, Reciprocating Instruments, Single File Preparation.

INTRODUCTION

Modern endodontics has been marked by technological innovations and techniques that have revolutionized root canal treatment. Nevertheless, one of the greatest challenges in clinical practice persists: endodontic retreatment. When primary treatment fails, whether due to persistent infections or technical inadequacies, the clinician faces the need to reintervene in a root canal system that is often complex and anatomically varied. In this context, complete removal of the obturation material is the most crucial initial step, as it may harbor pathogenic microorganisms that lead to failure (Hülsmann *et al*., 2011; Fatima *et al*., 2018).

Several techniques and instruments have been introduced over the years with the aim of facilitating obturation material removal and allowing a new approach to cleaning and shaping the canals (Purba *et al*., 2020). The advent of mechanized systems, especially reciprocating systems, has simplified the process, offering efficiency and reduced treatment time. However, despite these improvements, complete removal of the obturation material remains a substantial challenge, particularly in the apical third of root canals, where the complex anatomy imposes severe limitations (Rödig *et al*., 2014). At this point, a central question arises: could the enlargement of the instrument's diameter during retreatment offer an effective solution for obturation material removal, even in hard-to-reach regions?

Reciprocating instrumentation has been widely used, with its main advantage lying in the ability to

prepare the canal with a single instrument (Bürklein *et al*., 2012). However, when it comes to retreatment, the scenario changes significantly. The previously placed obturation material, often dense and tridimensionally adapted, presents a barrier to complete removal, and the diameter of the selected instrument can make the difference between effective cleaning and failure (Rödig *et al*., 2014; Bago *et al*., 2020).

A significant clinical question emerges: does the enlargement of the apical diameter, using an instrument immediately larger than the one employed in the initial preparation, promote more effective removal of the obturation material? Furthermore, the choice of kinematics—whether pecking motion or brushing motion—could play a significant role in cleaning efficacy. Traditional pecking motion focuses on the penetration of the instrument along the canal's axis, while brushing motion attempts to engage the canal walls in an effort to clean surfaces that are not typically reached by linear motions (Chicon *et al*., 2024).

However, little is known about how these variations influence the removal of obturation material specifically in the apical third, where complex anatomy and lateral canals often pose obstacles. The guiding question of this study is clear: does the use of a larger diameter instrument, combined with different kinematics, promote more efficient removal of obturation material in the apical portion of root canals during endodontic retreatment?

MATERIALS AND METHODS

Thirty human maxillary molars were obtained from the institution's tooth bank in accordance with the approval of the Ethics Committee for Research (approval no. 2.145.718).

Exclusion Criteria

Maxillary molars with separated roots and a minimum root length of 12 mm were selected. Teeth with developing roots, severe curvatures, or a length shorter than 12 mm were excluded. Periapical radiographs were taken after visual inspection. Teeth that had already undergone endodontic treatment were excluded.

Preparation Procedure

The teeth were removed from a 0.5% chloramine T solution in which they were stored and rinsed thoroughly with saline. After drying with gauze and compressed air, radiographs were taken in the buccopalatal and mesiodistal planes. Access cavities were created, and the pulp chambers were irrigated with 10 mL of 1% sodium hypochlorite (NaOCl). The extent of the mesiobuccal and distobuccal canals was determined using manual K-type files, size 10, inserted until the tip was visible at the apical foramen. The working length was established at 1 mm short of the total canal length. The canals were initially explored manually with size 10 and 15 K-files.

The 30 teeth were randomly divided into four groups of 15 specimens each. In Group I, the mesiobuccal canals were prepared with WaveOne Gold Small instruments. During preparation, 20 mL of 1% NaOCl was used for irrigation. After preparation, the canals were irrigated with 3 mL of 17% EDTA for 3 minutes, followed by aspiration and a final rinse with 10 mL of 1% NaOCl. The canals were then dried with size 30 paper points and obturated using the McSpadden technique (1980), with zinc oxide and eugenol-based sealer and WaveOne Small gutta-percha cones. After vertical compaction of the obturation with Paiva condensers, the coronal chamber was cleaned with alcohol-soaked cotton.

In Group II, the procedures were similar, but the mesiobuccal canals were prepared with WaveOne Gold Primary instruments and obturated with the corresponding gutta-percha cones. In Group III, the distobuccal canals were prepared with WaveOne Gold Small and obturated as previously described. Finally, in Group IV, the distobuccal canals were prepared with WaveOne Gold Primary instruments and obturated in the same manner.

The teeth were then positioned in silicone supports molded into 2 cm PVC rings, allowing for exposure of the tooth roots. The coronal portion was kept in contact with the silicone, allowing for repositioning of the teeth in their original orientation. The specimens were scanned with a Scandora 3D (Soredex) cone beam computed tomography (CBCT) machine, and the images were sequentially saved.

Retreatment Procedure

The teeth were retreated using a reciprocating instrument with a larger diameter than the one used in the initial preparation. In Group I, retreatment was performed with WaveOne Gold Primary (#25/07) instruments using brushing motion kinematics. After reaching the working length with insertion and removal movements, the instruments were laterally directed against the canal walls until no further resistance or obturation material was detected. Irrigation consisted of 20 mL of 1% NaOCl, followed by 3 mL of 17% EDTA, aspiration, and another 3 mL of 1% NaOCl. The canals were then dried with size 30 paper points.

In Group II, retreatment was performed with WaveOne Gold Medium (#35/06) instruments using the same brushing motion kinematics. In Group III, the canals were retreated with WaveOne Gold Primary using pecking motion, advancing in short strokes of 2-3 mm towards the apex while applying light pressure. The instrument was removed, cleaned, and the process repeated until no more obturation material was being displaced. The irrigation and drying protocols followed the same steps as described above. Group IV followed the same procedure but used WaveOne Gold Medium (#35/06) instruments.

After retreatment, the samples were repositioned in the supports and rescanned with CBCT. Using Image J software, the presence or removal of obturation material in the apical three millimeters of the canals was evaluated in the X, Y, and Z axes. The results were recorded and submitted for statistical analysis.

RESULTS

The data were subjected to two-factor analysis of variance (ANOVA) to evaluate the impact of instrument type (Primary or Medium) and the applied kinematics (brushing motion or pecking motion) on the removal of obturation material from the apical three millimeters. ANOVA revealed no significant differences between instrument groups ($F = 0.093$, $p = 0.762$) or between the different kinematics ($F = 0.093$, $p = 0.762$). Additionally, the interaction between the factors was not significant ($F = 0.093$, $p = 0.762$).

Table 1: ANOVA for Comparison between Instruments and Kinematics

Factor	Sum of Squares	df	F	p-value
Instrument type	0.025	1	0.093	0.762
Kinematics	0.025	1	0.093	0.762
Interaction (Instrument x Kinematics)	0.025	1	0.093	0.762
Residuals	9.700	36		

No significant differences were observed between the groups for the evaluated factors. To identify possible differences between the groups, Tukey's post-hoc test was applied, which did not indicate significant comparisons. Finally, logistic regression modeling demonstrated that neither the instrument type nor the kinematics applied significantly influenced obturation material removal. The coefficients of both factors were low and lacked statistical significance ($p > 0.74$).

Table 2: Logistic Regression Results

Variable	Coefficient	Standard error	Z-value	p-value	95% CI
Constant	0.099	0.551	0.179	0.858	[-0.981, 1.178]
Instrument Type	0.205	0.641	0.320	0.749	[-1.052, 1.462]
Kinematics	0.205	0.641	0.320	0.749	[-1.052, 1.462]

Neither the instrument type nor the kinematics significantly influenced the removal of obturation material.

Table 3: Percentage of Samples with Residual Obturation Material

Instrument	Kinematics	Samples with residual material	Total_samples
Medium	Brushing Motion	9 (60%)	15
Medium	Pecking Motion	9 (60%)	15
Primary	Brushing Motion	8 (53,33%)	15
Primary	Pecking Motion	9 (60%)	15

After statistical analysis, no significant differences were observed between the groups, and the results indicate that the use of a larger diameter instrument and brushing motion kinematics did not result in complete removal of obturation material.

DISCUSSION

The greatest challenge to achieving effective disinfection in endodontic retreatment is not bacterial resistance to procedures, but rather the difficulty in accessing and adequately cleaning the dentinal walls. This obstacle may be caused by iatrogenic changes during the initial treatment or by the presence of obturation material (Zehnder & Paqué, 2011). Complete removal of this material is a determining factor for the success of retreatment, as residual debris may harbor pathogenic microorganisms, leading to persistent infections and treatment failure (Ricucci *et al.*, 2009). The apical portion of root canals, in particular, presents considerable challenges due to its complex anatomy, often containing ramifications, accessory canals, and isthmuses (Rödig *et al*., 2014; De-Deus *et al*., 2020).

In this study, even with the use of larger diameter reciprocating instruments and different kinematics, a high percentage of residual obturation material was observed in some samples, reaching 60% in certain groups. This result reinforces the need to explore new approaches that overcome the limitations imposed by apical anatomy and the tridimensional adaptation of the obturation material.

The use of reciprocating instruments in retreatment facilitates faster and easier removal of obturation material compared to manual or rotary techniques (Zuolo *et al.*, 2013). However, the results of this study indicate that there were no significant differences between the evaluated groups in terms of

instrument type (Primary or Medium) or applied kinematics (Brushing Motion or Pecking Motion) for the removal of obturation material from the apical three millimeters of the canals. These findings confirm the widely reported difficulties in the literature in completely removing obturation material from the apical region, which is considered one of the most complex areas of the root canal system (Hülsmann *et al.*, 2011; Rödig *et al*., 2014).

While single-instrument reciprocating instrumentation has demonstrated efficiency in retreatments, it does not guarantee complete removal of obturation material in curved canals (Rossi-Fedele & Ahmed, 2017). De-Deus *et al*., (2018) evaluated apical enlargement of retreated canals with Reciproc (MWire) and Reciproc Blue, achieving enlargements from #25 to #40. Although significant obturation material removal occurred, complete removal was not achieved.

Another central aspect of this study was the analysis of instrument diameter influence on retreatment success. Apical enlargement of a contaminated canal is crucial for the success of endodontic treatment (Mickel *et al*., 2007; Saini *et al*., 2012). The hypothesis that the use of larger diameter instruments, such as WaveOne Gold Medium (#35/06), would be more effective in removing obturation material was tested. However, the results did not indicate significantly greater efficiency compared to smaller diameter instruments like WaveOne Gold Primary (#25/07). Although larger diameters may increase contact with canal walls, removal in the apical third remained limited. This difficulty may be attributed to the complex apical anatomy, which includes ramifications and irregularities (Hülsmann *et al*., 2011).

The literature suggests the need for complementary strategies to instrumentation to improve obturation material removal. Agitation of irrigating solutions may increase cleaning efficacy in lateral canals and the apical portion (Rossi-Fedele & Ahmed, 2017; Bago *et al*., 2020; De-Deus *et al*., 2020). Additionally, the use of gutta-percha solvents, either in the early stages, during, or after retreatment, may intensify the removal of residual material (Rossi-Fedele & Ahmed, 2017).

CONCLUSION

In endodontic retreatment, the use of a WaveOne Gold instrument with a larger diameter than the one selected for the initial preparation of the buccal canals of maxillary molars was not sufficient to completely remove obturation material from the apical third.

The adoption of brushing motion kinematics did not improve the number of samples considered free of obturation material in the apical portion.

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