Effect of different obturating techniques and sealers on the removal of filling materials during endodontic retreatment

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Abstract

Background: Adequate removal of previous root filling materials is an important objective during endodontic retreatment.

Aim: This study was aimed to evaluate the influence of obturation quality and sealer type on the removal of root filling materials during endodontic retreatment using micro-computed tomography (µ-CT).

Materials and Methods: Ninety extracted mandibular premolars were randomly assigned to two groups (n = 45) based on the type of sealer (AH Plus and BioRoot RCS) and three sub-groups based on the obturating technique used, i.e., cold lateral condensation, warm vertical compaction, and thermoplasticized injectable techniques. Specimens were scanned using µ-CT before and after retreatment to assess the amount of filling material, and time taken for removal was recorded.

Statistical Analysis: Data were analyzed using two-way analysis of variance and Tukey’s multiple post hoc test at 5% significance level.

Results: Filling debris percentage and retreatment time were not significantly affected by the type of sealer (P ≥ 0.05). The percentage of remaining filling material was higher in teeth obturated with thermoplasticized technique (P < 0.05). Significantly more filling material debris was observed in apical third (P < 0.05).

Conclusions: The type of obturating technique used for initial root canal treatment has influenced the amount of remaining filling material and retreatment time. Retractability of the BioRoot RCS sealer was similar to the AH Plus sealer.

Keywords: AH Plus; BioRoot RCS; micro-computed tomography; obturating techniques; retreatment

INTRODUCTION

When initial root canal therapy fails, the most conservative option is the retreatment procedure, which can resolve the infection by improving root canal debridement and disinfection, followed by placing a consistent homogenous three-dimensional re-obturation.[1] During retreatment, a substantial amount of root filling residue can be left along the canal walls, reducing the success rate.[2-4] Thus, the key factor that determines the success of retreatment is the ability to remove the originally obturated material completely from the root canals.

The difficulty in removing gutta-percha is directly related to the type of canal preparation, filling techniques as well as the type of sealers used.[5] Recently, introduced bio-ceramic sealers containing calcium silicate have exhibited excellent...
tissue healing with hydroxyapatite mineralization of dentin that promotes sealing of root canals. However, due to the deeper penetration into dentinal tubules and becoming harder after setting, their retreatability is a concern to clinicians.

Several modifications have been advocated to improve the efficacy of the cold lateral condensation (CLC) technique and a recently published meta-analysis stated that long-term outcome was similar for both lateral compaction and thermoplasticized method of obturation. However, in laboratory studies, it was proven that warm vertical compaction provides a greater amount of gutta-percha filled areas. Effective removal of these materials from the canals that were inadequately prepared and obturated is challenging and requires substantial effort and time.

Among the different methods used to assess the amount of remaining debris, three-dimensional micro-computed tomography (μ-CT) scanning was noninvasive, high-resolution imaging method that provides accurate quantitative analysis. Thus, the objective of this study was to evaluate the influence of cold lateral compaction, warm vertical condensation, or thermoplasticized injectable obturating techniques quality and the sealer type, on the removal of root filling materials during endodontic retreatment using μ-CT. The null hypothesis tested was; ability to remove the obturating material and the time required for the removal is not dependent on the obturating technique or the sealer type used.

MATERIALS AND METHODS

Ninety noncarious, extracted human mandibular premolar teeth with a single straight (<5°) root canals were collected. Teeth with reduced pulp spaces and calcified canals were discarded.

All teeth samples were mounted in cold-cured resin blocks with the simulation of the periodontal ligament. Standardized access openings were prepared, and working length was determined radiographically, the cleaning and shaping procedures were performed using MTwo rotary Ni-Ti files (VDW GmbH, Germany) up to a size of #35/.04 taper. The specimens were grouped based on the kind of sealer used (n = 45 each), i.e., AH Plus (DenTsply, Germany) or BioRoot RCS (Septodont, France) sealers and three sub-groups (n = 15 each) based on the type of obturating technique used, i.e., CLC, warm vertical compaction using elements system (System B™, Sybron Endo), and thermoplasticized injectable technique using i-Fill obturating system (Denjoy dental Co., Ltd., China).

After root canal obturations, the specimens were kept for 3 weeks at 37°C and 100% humidity and scanned for quantifying the root-filled area using μ-CT (X-radia Versa 500, Ziess, Germany). The three-dimensional data were analyzed using AVIZO software (Thermo scientific™, Germany), and the volume of filling material at each third of the root canal was recorded in cubic millimeters.

Root canal retreatment

In a standardized manner, gutta-percha was removed up to 2 mm from cement-enamel junction and 0.1 ml of Endosolv E (Septodont, France) was used for 30 s to soften the obturating material. Retreatment instruments M Two R1 (#15/.05) and M Two R2 (#25/.05) (VDW GmbH, Germany) were used to remove the filling material till the working length and the root canals were enlarged up to # 40/04 master apical file size. The time taken for the retreatment file to reach the working length (T1) and for removal of obturating material (T2) were recorded. Thus, the total time taken for the removal of the filling material was calculated as T1 + T2 using a digital stopwatch. When no scrap was seen on the instrument and in the irrigating solution flush out, the retreatment procedure was considered complete. Each rotary Ni-Ti instrument was discarded after preparing five root canals.

After retreatment procedure, specimens were scanned again under μ-CT to estimate the amount of remaining filling material. The total percentage of residual filling material and individually at different root regions were calculated using the formula: The amount of remaining filling material in the canal space divided by total canal space ×100.

Statistical analysis

Statistical analysis was performed using SPSS software (IBM SPSS; Version 20.0, SPSS SOFTWARE (IBM VERSION 20.0, CHICAGO; IL USA)). A two-way analysis of variance was used to compare the remaining amount of filling material within the root canals and to evaluate the amount of time taken for retreatment in each group. Pairwise comparisons among the groups were performed using Tukey’s multiple post hoc test. Statistical analysis was performed at 95% level of confidence, with the significance level established at P < 0.05.

RESULTS

All the samples exhibited residual filling material (15%–24%) irrespective of the sealer type or obturation technique used [Table 1]. Root canals obturated with lateral condensation technique exhibited less remaining filling material when compared to all other groups (P < 0.05). No statistically significant difference in gutta-percha and sealer removal was found between warm vertical compaction (WVC) and injectable gutta-percha obturation groups (P ≥ 0.05). The residual filling material was increased from coronal to
the apical third region of the root canals in all the groups [Figure 1].

The time required for removal was maximum for warm vertical compaction samples in both the sealer groups [Table 2]. Significantly lesser time was required for retreatment in teeth obturated with lateral condensation technique \((P \leq 0.05)\) compared to other groups. No statistically significant difference was observed in retreatment time between warm vertical and injectable obturation techniques \((P \geq 0.05)\).

**DISCUSSION**

Quick and efficient removal of root filling is the important step in retreatment that will allow us to do effective

| Table 1: Pair-wise comparisons of mean area percentage values of remaining filling material |
|---|
| Groups | Sub groups | Group 1 AHP with LAT | Group 1 AHP with WVC | Group 1 AHP with INJ | Group 2 BIO with LAT | Group 2 BIO with WVC | Group 2 BIO with INJ |
| Mean area of remaining filling material | 15.41 | 24.26 | 21.06 | 14.64 | 22.58 | 19.78 |
| Standard deviation | 6.00 | 6.57 | 8.05 | 4.09 | 6.14 | 7.20 |
| Group 1 AH Plus sealer | AHP with LAT - | AHP with WVC \(P=0.0043^{*}\) - | AHP with INJ \(P=0.0492^{*}\) \(P=0.7523\) - |
| Group 2 BioRoot RCS sealer | BIO with LAT \(P=0.9996\) \(P=0.0015^{*}\) \(P=0.0416^{*}\) - | BIO with WVC \(P=0.0359^{*}\) \(P=0.9800\) \(P=0.9873\) \(P=0.0143^{*}\) - | BIO with INJ \(P=0.0374^{*}\) \(P=0.4097\) \(P=0.9942\) \(P=0.0584^{*}\) \(P=0.8418\) - |

* \(P<0.05\) statistically significant; \(P>0.05\) non-significant. LAT: Lateral condensation technique, WVC: Warm vertical compaction technique, INJ: Injectable gutta-percha obturation, AHP: AH Plus sealer, BIO: BioRoot RCS sealer

| Table 2: Comparison of scores of retreatment time in seconds by Tukey’s multiple post hoc procedures |
|---|
| Groups | Subgroups | Group 1 AHP with LAT | Group 1 AHP with WVC | Group 1 AHP with INJ | Group 2 BIO with LAT | Group 2 BIO with WVC | Group 2 BIO with INJ |
| Mean time in seconds | 236.27 | 310.53 | 281.67 | 233.40 | 306.53 | 285.33 |
| Standard deviation | 19.25 | 56.62 | 33.97 | 26.00 | 63.35 | 32.13 |
| Group 1 AH Plus sealer | AHP with LAT - | AHP with WVC \(P=0.0002^{*}\) - | AHP with INJ \(P=0.0425^{*}\) \(P=0.4131\) - |
| Group 2 BioRoot RCS sealer | BIO with LAT \(P=0.9990\) \(P=0.0002^{*}\) \(P=0.0254^{*}\) - | BIO with WVC \(P=0.0003^{*}\) \(P=0.9998\) \(P=0.5803\) \(P=0.0002^{*}\) - | BIO with INJ \(P=0.0219^{*}\) \(P=0.5661\) \(P=0.9999\) \(P=0.0126^{*}\) \(P=0.7323\) - |

* \(P<0.05\) statistically significant; \(P>0.05\) non-significant. LAT: Lateral condensation technique, WVC: Warm vertical compaction technique, INJ: Injectable gutta-percha obturation, AHP: AH Plus sealer, BIO: BioRoot RCS sealer

Figure 1: Micro-computed tomography images; root canals obturated with lateral condensation before and after retreatment at coronal (1a), mid-root (1b), and apical (1c) regions; root canals obturated with warm vertical compaction before and after retreatment at coronal (2a), mid-root (2b), and apical (2c) regions; root canals obturated with thermoplasticized injectable technique before and after retreatment at coronal (3a), mid-root (3b), and apical (3c) regions
cleaning, disinfection, and refilling of the root canals. BioRoot RCS was reported to leach high levels of calcium, forms calcium phosphate crystals when in contact with the physiologic solution. Moreover, AH Plus sealer evoked greater calcitonin gene-related peptide release, whereas, calcium silicate-based sealers are reported to lessen peptide release, reducing the potential for pain and neurogenic inflammation. The percentage of the total amount of root-filled space was 86% for warm injectable gutta-percha techniques in the present study. In accordance with previously reported results, the use of Endosolv was restricted to a coronal third of the root canal for easy penetration of the rotary files that have simplified the removal of root filling materials. The percentage of root-filled area compared to lateral compaction and injectable gutta-percha techniques in the present study. The use of solvents throughout the reinstrumentation process can cause more accumulation of residual materials in canal irregularities and isthmuses. MTtwo R files contain a cutting tip with a constant helical angle, that ensures easy progression of the instruments into the gutta-percha filling, without the need to follow a crown-down instrumentation sequence. As better removal of filling material by MTtwo R files was reported compared to other systems, these files were used. The apical enlargement was done two sizes beyond the initial preparation size of the root canal. It was recommended that, preparing the root canals to a larger size than the width prepared in initial root canal treatment, improves the cleaning ability during retreatment. To avoid the inter-operator variables, only one clinician has performed the whole experimental procedures.

To overcome the drawbacks of earlier assessment methods such as sectioning and radiographic methods to assess the residual root-filled materials volume, three-dimensional µ-CT scanning was used. This noninvasive technique enabled us to differentiate the canal walls and residual debris and minimized the operational bias in the interpretation of the results. In accordance with previously reported results, warm vertical compaction has provided the highest percentage of root-filled area compared to lateral compaction and injectable gutta-percha techniques in the present study. The percentage of root-filled space was 86% for warm vertical compaction, 83% for injectable technique, and 77% for lateral compaction. Irrespective of the sealer type or obturation technique used, all the groups have shown some amount of remaining filling material corresponding to the results of earlier studies. The overall percentage of remaining root canal filling material in this study was 15%–24%, which is slightly higher than the previous µ-CT investigated reports of straight root canals. However, a large amount of residual filling material (11%–62%) was reported after retreatment in curved canals. The percentage of the total amount of remaining filling material was maximum in groups that were obturated with WVC. This can be attributed to the ability of this system to plasticize the gutta-percha, allowing better compaction of the material into the root canal irregularities. The total quantity of remaining debris was not significantly different between the groups that were obturated with WVC and thermoplasticized injectable technique as both these techniques utilize heat to condense the gutta-percha.

The amount of remaining filling material increased from coronal third to middle third and more amount was left in the apical region of the root canal. These results were correlating with other studies in that maximal residual filling material was remained in the apical portion of the root canals. This finding might be due to the difficulty in engaging the rotary instruments in the apical root region and also because of the filling material lodging into the canal irregularities, making it difficult to remove during retreatment. On the other hand, the use of solvent and speed of the rotary instruments used, causing plasticization of gutta-percha, might have enhanced the removal of filling material from the coronal region.

The quantity of remaining filling material and the time taken to perform the retreatment procedure for bioceramic sealer was not different from the AH Plus sealer. Contrary to these results, more sealer remnants of BioRoot RCS were observed in other studies. The variation in these results can be explained by the differences in the methodology, as they have tested different retreatment files and evaluated using two-dimensional methods.

The retreatment time taken for the cold lateral compaction technique was found to be considerably less when compared to warm vertical compaction and thermoplasticized injectable techniques. Due to the nonhomogeneous mass and comparatively lesser obturated volume in lateral compaction obturations, the rotary files can easily penetrate and remove the filled material. This result is in harmony with other studies, which showed that retreatment time was maximum for the teeth that were initially obturated using thermoplasticized techniques. The null hypothesis was partially rejected as remaining filling debris and the time taken for the removal of filling material was dependent on the type of obturating technique used.

The shortcoming of this study design was, working length and the size of final apical preparation are familiar to the operator and thus does not mimic the clinical scenario. Despite the numerous advantages, in vivo application of µ-CT is not justified due to high radiation exposure and expenses involved with this technique.

**CONCLUSIONS**

The percentage of filling material left in canals obturated with thermoplasticized techniques was more. Residual
filling material volume increased from coronal to the apical third of the root region. The retreatability of the BioRoot RCS sealer was similar to the AH Plus sealer.

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**Conflicts of interest**
There are no conflicts of interest.

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