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ORIGINAL ARTICLE

Effect of Ultrasonic Combined with Solvent on Gutta-Percha and Bioceramic Sealer Removal in Middle and Apical Third of the Root Canal: An ex vivo study

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ABSTRACT

Objective: This study aims to investigate the effectiveness of ultrasonic tip with and without solvent in removing gutta-perca and bioceramic sealer from the middle and apical third of the root canals. **Methods**: This is a true experimental study with randomized pretest-posttest control group design. Eighteen freshly extracted straight single-rooted mandibular first premolars were confirmed by CBCT and selected. The teeth were decoronated until a length of 16 ± 0.5mm. The teeth were prepared and obturated using gutta-percha and bioceramic sealer with a hydraulic condensation technique. Pre-instrumentation CBCT imaging of all teeth was carried out to obtain the initial volume of the obturation material. After incubating for 30 days, the treated teeth were randomly divided into three groups (n = 6): ultrasonic and xylene, ultrasonic and orange oil, and ultrasonic only. Post-instrumentation CBCT was carried out and the amount of obturation material removed was calculated using CT Analyser. The two-way ANOVA was used to determine the solvent and location interaction. **Results**: The results showed that there was no significant difference among the groups based on the treatment and location ($p > 0.05$). In addition, no significant interaction was found in relation to the cleanliness of the root canal ($p > 0.05$). **Conclusion**: There was no difference in the effectiveness of ultrasonic obturation material cleaning with and without endodontic solvents. Based on the results, the obturation material with the most residue is a sealer.

Key words: bioceramic sealer, orange oil, retreatment, ultrasonic, xylene

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INTRODUCTION

The root canal treatment aims to eliminate pathogenic microorganisms and has a success rate of 86-98%. Despite the high success rate, patients do not respond to early treatments in some cases due to the failure to eliminate microorganisms or infection before and after initial treatment respectively.[1-4] Consequently, nonsurgical endodontic retreatment needs to be first considered as a conservative approach. The retreatment procedure is similar to the conventional treatment, and only differs in the method of removing the obturation materials. Several methods have been proposed for the retreatment including the use of heat, solvent, hand instruments, nickel-titanium rotary treatment file, ultrasonic tip, Neodymium doped Yttrium Aluminium Perovskite (Nd-YAP) laser, or the combination of these techniques.[1,5,6]

Gutta-percha is the most frequently used obturation material but it has poor adhesion to dentin, therefore, a sealer is needed.[7] Meanwhile, sealers are categorized based on the main chemical substances namely zinc oxide eugenol, calcium hydroxide, glass ionomer, silicone, resin, and bio-ceramic.[8,9] To enhance the removal of gutta-percha in root canal retreatment, several studies recommend the use of solvents. Gutta-percha is softened using chemical solvents or heat such as an ultrasonic instrument.[10] However, the removal by softening is recommended to avoid damaging the tooth structure. The use of solvent aims to decrease the resistance of obturation materials in the root canal but the application sometimes needs to be repeated to reach one-third of the apical area.[11] Several solvents used to soften gutta-percha include chloroform,

methyl-chloroform, eucalyptol oil, halothane, rectified turpentine, and xylene. These solvents are relatively toxic and are to be applied only when necessary.[4]

Solvents are often combined with rotary treatment file, Bhagavaldas et al. found that D-RaCe and MtwoR rotary systems with and without solvent had the same effectiveness.[12] Another study also showed that the use of Pro-Taper Universal Retreatment system (PTUR) with chloroform has the highest obturation residue since chloroform dissolves gutta-percha and its consistency was more flowable to infiltrate dentin irregularity and dentinal tubules.[13] Furthermore, a study conducted by Takahashi et al. which used PTUR and chloroform showed that gutta-percha was difficult to remove using solvent because it formed a layer that adhered to the root canal wall.[14] Retreatment with ultrasonic tip and orange oil for removing obturation materials was more effective compared to manual instruments and rotary retreatment files. The ultrasonic tip removes gutta-percha mechanically and the heat produced from frictions converts the obturation materials to thermoplastics.[10,15] Ultrasonic instruments have been utilized in dentistry since 1950 as a part of clinical routine procedures.[16]

The major concern with using solvents include toxicity and the sedimentation of obturation materials which covers dentinal tubules. Horvath et al. stated that solvent causes more sediment and suggest its use only when the working length is not achieved.[17] There are contradictions regarding the effect of solvent in gutta-percha removal. Based on a previous study, the coronal third of root canal had a better access of suction and irrigation tips, as well as the ability of instruments to touch its walls. The coronal third also showed more open tubules than the other parts. Therefore, the removal of filling material in the coronal region was considered easier.[18,19] Based on another study, all retreatment techniques demonstrated good results on the middle third of root canals,[15] while Kumar et al. found that more obturation materials residue were found in a third of the middle area.[20] According to previous study, apical third had the most number of accessory canals (17%), followed by the middle (8.8%) and coronal (1.6%) thirds.[21] Similarly, Vertucci et al. found lower occurrence of ramifications in the middle (11.4%) and coronal (6.3%) thirds compared to the apical third.[22]

An ultrasonic instrument with a special tip is used for re-treating root canals. Ultrasonic has been used in daily practice. In previous studies, the use of solvent triggers sedimentation that left more obturation materials.[12,13,23] The difference between this study and the previous studies was in this study an ultrasonic tip was used without solvent. The aim of this research was to investigate the effectiveness of ultrasonic tip with and without solvent in removing obturation materials (gutta-percha and bioceramic sealer) from root canal walls in the middle and apical root third of the canals. The null hypothesis was that no significant difference in ultrasonic effectiveness with and without solvent on gutta-percha and bioceramic sealer in middle and apical third of the root canal.

METHODS

Sample acquisition

This type of research is a true-experimental with the pretest-posttest control group design. This study was conducted in accordance with all the provisions of the local human subjects' oversight committee's guidelines and policies of the Research Ethics Committees Faculty of Dentistry, Universitas Trisakti No: 337/S2-Sp/KEPK/FKG/3/2020. The sample size calculation used G*Power. A total of 31 humans extracted mandibular first premolars were collected after obtaining the patient's informed consent. Straight single root teeth with fully formed apices were selected. Teeth with root caries, root resorption, fracture, calcified canal and roots with curvatures higher than twenty degrees were excluded. The teeth were scanned using Cone-beam computed tomography CBCT (Accuitomo 3D, Morita, Japan) to select the ones with patent and straight canals without bi/trifurcation, and 24 teeth fulfilled these criteria. Eighteen teeth were then elected by using simple random sampling. They were decoronated with a water-cooled, low-speed double-faced diamond disc (Meisinger, USA) leaving the remaining root segment to be approximately 16±0.5 mm long, while K-File #10/.02 (SybronEndo, Kerr, USA) was inserted into the root canal until it was visible at the apical foramen. The working length was established from this length measurement. Furthermore, the samples were instrumented using ProTaper Next rotary instrument (Dentsply, Switzerland) up to size X3 with single length technique and irrigated with 2 mL of 5.25% sodium hypochlorite/NaOCl (Cerkamed, Poland) using a 30G side vented irrigation needle (Terumo, USA) between instrumentations. The root canal was dried using paper point (Inline, Indonesia) and obturated with a bioceramic sealer (Sureseal RootTM, Sure Endo, Korea) as well as X3 gutta-percha (ProTaper Next, Dentsply, Switzerland) by using single cone technique. Excessive sealer was cleaned, and the gutta-percha cone was cut 1 mm from the coronal part with heat carrier plugger (Hu-Friedy, USA). Moreover, the coronal part of the root canal was covered with temporary restoration materials (Cavitron, GC, Japan), while the initial volume of root canal filling was analyzed using Cone-beam computed tomography/CBCT (Accuitomo 3D, Morita, Japan). The samples were then stored in an incubator (Memmert, USA) at 370C for 30 days to set the sealer completely.

Endodontic retreatment procedure

The samples (n = 18) were divided randomly into 3 groups (n = 6) of obturated canals retreated with

ultrasonic+xylene (group1), ultrasonic+ orange oil (group 2), and ultrasonic only (group 3). The reservoir for gutta-percha solvent application was made 2 mm depth from coronal/orifice parts of the root canal with Gates Glidden #3 drill (Mani, Japan). 0.4 mL of the solvent was delivered to the reservoir, while ultrasonic (Newtron P5 XS B. LED, Satelec, Acteon, France) was then used to disassemble the obturating material after 2 minutes. Every 30 seconds, root canal debris was cleaned using 2 mL 5.25% NaOCl (Cerkamed, Poland) through a 30G side vented irrigation needle (Terumo, USA) and then the solvent was reapplied. This procedure was repeated until the working length was reached, then the instrumentation was stopped. Furthermore, apical patency was confirmed using K-file #10/.02 (SybronEndo, Kerr, USA), while the final irrigation was carried out using 2 mL 5.25% NaOCl, 2 mL 17% EDTA (OneMed, Medicom, Indonesia), and 2 mL 5.25% NaOCl sequentially. The root canal was then dried with paper points and stored in a dry state for further CBCT analysis.

Assessment of the root canal cleanliness with CBCT

The cleanliness of the root canal wall was evaluated by determining the percentage disparity between the initial and residual volume using the Accuitomo 3D CBCT scan (Morita, Japan). The samples were scanned at 87 kV and 5mA with a FOV of 40x40, while the results showed a series of images in 16-bit DICOM format, which were 3D images of the sample represented in the form of slices in the trans-axial plane. Furthermore, the DICOM image was first converted into an 8-bit bitmap as an adjustment step for processing and analysis, while image conversion was performed using Fiji/ImageJ software and DataViewer (Bruker Micro-CT, Köntich, Belgium). The scanned data were also rescaled using Fiji/ImageJ to produce a higher apparent resolution at 40 micrometers/pixel. After this step, the sample images were reoriented and sorted using the DataViewer, which was then segmented using a thresholding process to distinguish between the root canal filling portion and the dentin. Moreover, the samples were analyzed by calculating the volume of the root canal filling, while segmentation and analysis processes were carried out with CT Analyzer software (Bruker Micro-CT, Köntich, Belgium). The areas studied were at 10 mm and 5 mm from the middle and apical third respectively, while the morphometric analysis on the volume of obturation material (in mm^3) was calculated before and after the retreatment procedure. Furthermore, the difference between the initial and final obturation material volume was converted into a percentage. Figure 1 shows the scanning result from CBCT before and after retreatment procedures, while Figure 2 shows the segmentation and analysis processes with CT Analyzer software. The samples were examined blindly by two dental radiographers.

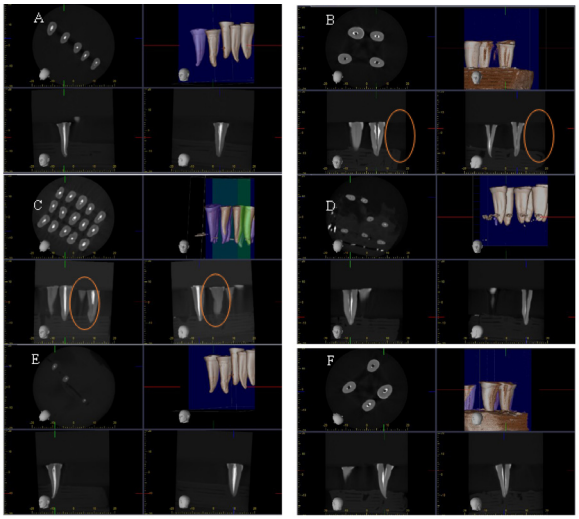

Figure 1. Scanning result from CBCT. A. Before retreatment (xylene). B. After retreatment (xylene). C. Before retreatment (orange oil). D. After retreatment (orange oil). E. Before retreatment (non-solvent). F. After retreatment (non-solvent).

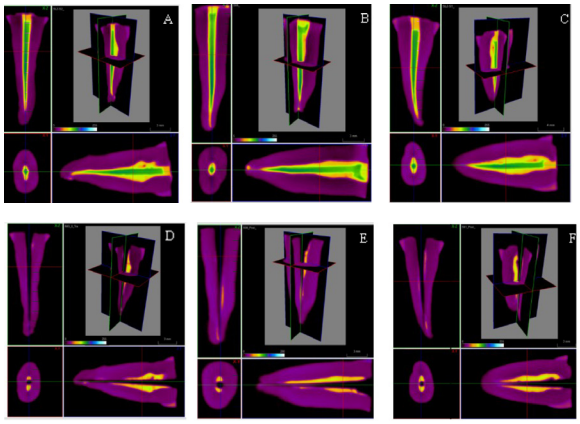

Figure 2. A-C (Before retreatment). A. Xylene. B. Orange oil. C. Non-solvent. D-F (After retreatment). A. Xylene. B. Orange oil. C. Non-solvent. Gutta-percha (green). Sealer (yellow to orange). Tooth (purple).

This is a laboratory experimental study with a randomized Pre and Post-test Control Group design. The normality and homogeneity of data were analyzed using Shapiro-Wilk and Levene test, while the differences among the three groups on the two root canal locations were tested with the two-way ANOVA. All data were analyzed using SPSS statistic 25 software (SPSS Inc, Chicago, USA).

RESULTS

The normality and homogeneity test showed that the data were distributed normally and homogenously with $p > 0.05$. The average percentage volumes of the residual obturation materials in the middle and apical

Table 1. Percentage volume of the removed obturation material in tested groups.

Group (%)						
Xylene (Middle third) (n = 6)	Xylene (Apical third) (n = 6)	Orange oil (Middle third) (n = 6)	Orange oil (Apical third) (n = 6)	Non-Solvent (Middle third) (n = 6)	Non-Solvent (Apical third) (n = 6)	p
59.41 ± 20.49 (CI 39.46 – 79.35)	70.45 ± 26.94(CI 50.51 – 90.39)	67.75 ± 21.65 (CI 47.81 – 87.70)	78.01 ± 16.99 (CI 58.07 – 97.95)	59.24 ± 28.19 (CI 32.29 – 79.18)	52.33 ± 27.10 (CI 32.39 – 72.27)	0.588

*Two-way ANOVA ($p < 0.05$); CI (95% Confidence Interval)

thirds is presented in Table 1. The two-way ANOVA shows that there were no significant differences among the groups based on treatment and location with $p > 0.05$. There was also no significant interaction between the treatment and location toward the cleanliness of the root canal with $p > 0.05$.

DISCUSSION

In non-surgical endodontic retreatment, obturation materials must be removed from the root canal. This procedure aims to remove necrotic tissue and microorganisms that were identified as the cause of failure in previous treatments.[24,25]

The total cleaning of the obturation material from the root canal is not achieved in all the groups as demonstrated by the percentage difference between the initial and the final volume. Another study carried out using the ProTaper Universal Retreatment System to clean the obturation material namely gutta-percha with 3 different sealers including bioceramic, MTA-based, and resin epoxy-based showed that residues were still present after the procedure.[26] Furthermore, Hess et al. found that the conventional retreatment technique does not always clean the bioceramic sealer completely. Another study also stated that the nickel-titanium and ultrasonic rotating instruments are not effective in cleaning the MTA-based obturation.[27] Takorova et al. using 3 instruments namely ProTaper Universal Retreatment File, hand instrument, and ultrasonic on obturation material including gutta-percha and bioceramic sealer also stated that relative cleaning of obturation material was not achieved in any location inside the root canal.[13]

Based on the result, there is no significant difference between xylene, orange oil, and the non-solvent in terms of cleaning the obturation material in the root canal. This is in line with Saglam et al. which stated that there is no significant difference in terms of obturation material cleaning with solvents including chloroform, Endosolv R, and without solvent.[25] The result is also consistent with Hwang et al. which showed that there is no significant difference in the use of chloroform, xylene, EndoSolv R, EndoSolv E, and non-solvent in terms of obturation material cleaning.[28] Xylene and orange oil have the same level of effectiveness in dissolving gutta-percha.[29] Therefore, the ultrasonic tip is applicable as a single instrument along with nonsurgical endodontic retreatment conducted in daily practice. The use of solvents is not necessary to minimize the risk of toxicity, but when retreatment needs to be carried out in the curved root canal, the application of other instruments is to be considered. However, this result is contradictory to other studies which showed that the non-solvent group is easier to clean because the gutta-percha is softened by the solvent and penetrates the dentinal tubules, thereby becoming more difficult to be cleaned.[14,16,17]

There is no significant difference between the solvent and non-solvent groups in the cleanliness of the obturation material because the solvent is more effective in dissolving the gutta-percha and non-bioceramic sealer, but not for the bioceramic.[30] The cleaning of the obturation material in the non-solvent group has the same level of effectiveness. This is because the heat from the ultrasonic instrument softens the gutta-percha on both the solvent and non-solvent groups.[13]

The residual obturation material in all groups is bioceramic sealer as shown in the CBCT analysis result, where gutta-percha is in green color while bioceramic sealer ranges from yellow to orange. This is in line with another study which mentioned that the most residual material during the retreatment procedure is the sealer.[31] Furthermore, the several characteristics of the bioceramic material contribute to the cleanliness of the root canal. The material is attached through a chemical bond inducted from the interaction of the mineral infiltration zone and the apatite crystals precipitation, as well as through the attachment of micromechanics caused by the cement plug inside the dentinal tubules, thereby producing a unique bond between the calcium silicate material and dentin. This biomineralization activity increases the adhesion and resistance toward the dislocation of dentin, while the hardness of the material after setting complicates the sealer cleaning from the root canal during retreatment.[32]

A study carried out using chloroform to clean the Endosequence BC sealer showed that the solvent does not escalate the cleaning of a bioceramic sealer, in addition, chloroform delays the cleaning of iRooT SP from the root canal.[32] Several studies also showed that

hard paste such as bioceramic sealer is more effectively cleaned using an ultrasonic instrument.[11,27]

The descriptive analysis results demonstrate a better obturation material cleaning with the combination of ultrasonic and orange oil on the apical third. Hence, orange oil is recommended as a suitable solvent especially on the apical third area because it has lower toxicity compared to xylene.

Although the obturation material was not cleaned or removed completely, the major objective was to access the apical area of the root canal to adequately carry out cleaning and shaping. The endodontic regular procedure was then conducted to complete the root canal treatment procedure. It is recommended that the cleaning and shaping procedures follow the crown-down approach to minimize the extrusion of irritants in the periradicular tissue and widening of the apical part to ensure complete debris cleaning.[4] The cleaning and enlarging of the root canal are needed to remove the filler residue, necrotic tissue, and microorganisms.

This study is limited because it was only conducted on the mandibular first premolars with a single and straight root but did not consider other retreatment methods such as manual or rotary retreatment file. The clinical application of the results is that the use of solvent including xylene and orange oil does not play an important role in the cleaning of obturation material such as gutta-percha and bioceramic sealer. Therefore, the use of solvents is not necessary to minimize toxicity, while the ultrasonic instrument is applicable for nonsurgical endodontic retreatment.

CONCLUSION

There is no difference in the effectiveness of ultrasonic with or without endodontic solvents in the total cleaning of obturation materials namely gutta-percha and bioceramic sealer in the middle and apical third of the root canal.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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