

Comparison of Obturation Quality in Modified Continuous Wave Compaction, Continuous Wave Compaction, Lateral Compaction and Warm Vertical Compaction Techniques

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Abstract

Objectives: The aim of this study was to introduce modified continuous wave compaction (MCWC) technique and compare its obturation quality with that of lateral compaction (LC), warm vertical compaction (WVC) and continuous wave compaction techniques (CWC). The obturation time was also compared among the four techniques.

Materials and Methods: Sixty-four single-rooted teeth with 0-5° root canal curve and 64 artificially created root canals with 15° curves in acrylic blocks were evaluated. The teeth and acrylic specimens were each divided into four subgroups of 16 for testing the obturation quality of four techniques namely LC, WVC, CWC and MCWC. Canals were prepared using the Mtwo rotary system and filled with respect to their group allocation. Obturation time was recorded. On digital radiographs, the ratio of area of voids to the total area of filled canals was calculated using the Image J software. Adaptation of the filling materials to the canal walls was assessed at three cross-sections under a stereomicroscope (X30). Data were statistically analyzed using ANOVA, Tukey's post hoc HSD test, the Kruskal Wallis test and t-test.

Results: No significant difference existed in adaptation of filling materials to canal walls among the four subgroups in teeth samples ($P = 0.139$); but, in artificially created canals in acrylic blocks, the frequency of areas not adapted to the canal walls was significantly higher in LC technique compared to MCWC ($P = 0.02$). The void areas were significantly more in the LC technique than in other techniques in teeth ($P < 0.001$). The longest obturation time belonged to WVC technique followed by LC, CW and MCWC techniques ($P < 0.05$). The difference between the artificially created canals in blocks and teeth regarding the obturation time was not significant ($P = 0.41$).

Conclusion: Within the limitations of this in vitro study, MCWC technique resulted in better adaptation of gutta-percha to canal walls than LC at all cross-sections with fewer voids and faster obturation time compared to other techniques.

Keywords: Adaptation; Root canal obturation; Root canal filling

Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2015; Vol. 12, No. 2)

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Received: 5 August 2014

Accepted: 28 December 2014

INTRODUCTION

Sealing the root canal system is an important step in root canal treatment for a successful outcome [1]. Several techniques and materials have been introduced for a three-dimensional obturation with higher density and homogeneity

[2]. Void-free filled canals carry a lower risk of apical periodontitis [3, 4]. Gutta-percha has long been used as a popular root filling material. The chemical and physical properties of gutta percha enable its application in several obturation techniques [5, 6].

Cold LC is a successful technique due to its simplicity, not requiring specific and expensive instruments and low cost [7]. Disadvantages of this technique include risk of void formation, inadequate adaptation of root filling material to the root canal walls and partial filling in certain hard-to-reach areas of the root canal system [8, 9]. Schilder [2] introduced WVC technique to improve the obturation quality in root canal irregularities. In this technique, he used heat-softened gutta-percha, and different sizes of pluggers to pack it.

The main advantages of thermoplasticized gutta percha techniques include better adaptation to root canal complexities, lower risk of void formation and creating a dense filling [10, 11]. CWC technique is a method of root canal filling with thermoplasticized gutta percha [12] using tapered pluggers to pack the heat-softened gutta-percha into the root canal system. In comparison to WVC technique, the CWC technique has the advantage of enhanced application and faster packing of gutta percha into the root canal system [13]. However, WVC technique may still be time consuming in many cases. Moreover, cleaning the remaining gutta percha at the orifice and coronal area is difficult. For the purpose of simplification and acceleration of obturation in this technique, we designed MCWC technique, which does not require removal of coronal gutta percha from the canal walls after down packing. Several methods are available to evaluate the quality of root canal filling. Techniques adopted by previous studies for this purpose include stereomicroscopic assessment of root canal cross sections [14], radiographic examination [15], evaluation of the adaptation of filling materials to root canal walls using a split-tooth model [16], micro-computed tomographic analysis [17] and weighting the gutta-percha to examine the obturation density [18]. The aim of this study was to compare the obturation quality of root canals by 1) digital radiography and finding and measuring the size of voids, and 2) ste-

reomicroscopic examination of gutta-percha and sealer adaptation to root canal walls in LC, WVC, CWC and MCWC techniques.

MATERIALS AND METHODS

Sixty-four artificially created root canals with 15° curves in transparent acrylic blocks (Nissin Co., Kyoto, Japan), and 64 teeth with 0-5° curved single root canals and minimum root length of approximately 12 mm with no visible cracks or resorption and mature apices were evaluated. Sixteen artificially created root canals in blocks and 16 teeth canals were filled with each method. The extracted teeth were immersed in 1% chloramine-T solution for three days. The crowns were cut with tapered fissure diamond burs under water coolant.

Preparation of canals in acrylic blocks and teeth

The teeth and artificially created root canals were prepared using standard Mtwo rotary instruments (VDW, Munich, Germany) to a final rotary apical size of 40/0.06. MD-ChelCream (Meta Biomed Co., Seoul, Korea) was used as the lubricant and 5.25% sodium hypochlorite was used as the irrigating solution. In teeth, working length (WL) was determined by inserting a #10 k-file (Dentsply co, Munich, Germany) into the canal until its tip was visible at the apex; 1mm was subtracted from this value to obtain the WL. In artificially created root canals in blocks, WL was visible in the transparent acrylic block.

Obturation

In this study, the efficacy of the four obturation techniques was evaluated. The artificially created root canals in blocks and the teeth root canals were divided into four subgroups of 16 each and coded randomly. One operator filled all canals by gutta percha (Meta Biomed Co. Ltd, Cheongju City, Chungbuk, Korea) and AH Plus sealer (Dentsply Co., Munich, Germany) using one of the four obturation techniques.

-LC technique:

A standard #40 or #45 gutta percha point with regard to canal size was selected and placed in the root canal. Tug back was ensured. AH Plus sealer was prepared according to the manufacturer's instructions and introduced into the canal using a #40 k-file (VDW Co., Munich, Germany). The tip of the master gutta percha cone was coated with sealer and placed 0.5 mm short of the WL in the canal. LC was done by inserting a size B spreader (Maillefer Co., Switzerland) 1 mm short of the WL next to the master gutta percha point, and #20 and #25 gutta percha cones were used as accessory cones.

-WVC technique:

A 40/0.06 tapered gutta-percha cone was inserted 1mm short of the WL and examined for tug-back. In case of absence of tug back, the tip of the master cone was cut until tug back was achieved. The sealer was applied to the canal walls using a #40 k-file. The tip of the master gutta percha cone was coated with sealer and it was placed in the canal. A heating device and Martin pluggers (Dentsply Co., Switzerland) were used to down pack and adapt the gutta percha to the canal walls. The remaining coronal space was then filled by warming and packing 3 mm segments of #80 gutta-percha cones.

-CWC technique:

A 40/0.06 tapered gutta-percha cone was placed 1mm short of the WL and examined for tug back. The sealer was applied to the canal walls using a #40 k-file. The tip of the master gutta percha cone was coated with sealer and placed in the canal. A system B heat source (SybronEndo, Orange, CA, USA) at 200°C was used. A medium- size tip was placed on the System B heat source with a rubber stop set at 3-5 mm short of the WL. The remaining steps were performed as described by Buchanan [13]. After removing the coronal and middle portions of the fillings, packing was fol-

lowed by injecting gutta percha in 3-mm increments into the canal. A cordless gutta percha obturation gun (E and Q Master, Meta Biomed Co) with #23 gauge needle was set on 180°C and gutta-percha pellets (Meta Biomed Co. Ltd, Cheongju City, Chungbuk, Korea) and Martin pluggers were used for back filling.

-MCWC technique:

A 40/0.06 tapered gutta-percha cone was placed 1mm short of the WL and examined for tug back. The sealer was applied to the canal walls using a #40 k-file. The master gutta percha cone was coated with sealer and placed into the canal. A system B heat source with a medium-size tip was set at 200°C and used to continuously pack gutta percha until reaching 3-5 mm short of the WL. Gutta percha was cut at the orifice and packed. Next, using a hot plugger, gutta-percha was condensed apically into the canal. Then the plugger was brought out of the canal without trying to remove the remaining coronal and middle portions of the cone. The created space in the coronal and middle part of the canal was back filled by heat-softened gutta percha with cordless gutta percha obturation gun in one move and then the obturation material was packed at the orifice with a plugger.

Sample Analysis

The time taken for obturation of each root canal was recorded using a stopwatch to compare the obturation times among different groups. Time of obturation was calculated from the introduction of sealer into the root canal until cutting the gutta-percha at the canal orifice and condensing it.

To radiographically examine the presence of voids in the first step of the study, digital radiographs were taken of all canals using a digital radiographic sensor (Kodak RVG 5100, Eastman Kodak Company, Trophy S.A., Marne-la-Vallée, France) and XGenus dental X ray unit (DeGotzen, Roma, Italy) (Figure 1).



Fig 1. Radiographs of teeth root canals and artificial root canals in acrylic blocks filled using (A) LC (B) WVC (C) CWC and (D) MCWC techniques.

A long tube was used and the distance between the tube and the sensor surface was about 5 cm. The exposure time for each model was 0.125 second and the voltage was 70kV. Then the radiographs were saved in TIFF format. The quality of obturation and presence of voids were assessed by two endodontists independently. The size of voids was measured with Image J software (Image J Inc., Java, Version 1.46) by counting and summing the void pixels.

In the second step of the study, filled canals in acrylic blocks and teeth were cut perpendicular to the length axis at 3, 6, and 9 mm distances from the endpoint. Teeth sections were immersed in 17% EDTA for one minute and then in 5.25% NaOCl for one minute followed by rinsing with normal saline [19]. Photographs were taken of the sectioned areas using a digital camera (AM423x dinoEye digital eyepiece) mounted on a stereomicroscope (Nanjing Sunny Optical Instrument Co., Ltd., Nanjing, China) at X30 magnification (Figure 2). These images were saved by Dino Capture software (Dino-lite, version 1.4.0.B) in TIFF format.

To evaluate the adaptation of filling materials to root canal walls, these photographs were analyzed blindly by two independent observers using Image J software.

Then, the results of artificial root canals in acrylic blocks and teeth were compared.

Radiographs were analyzed based on the following criteria:

- Presence of voids: The ratio of void areas to total filled root canal area was calculated.
- Adaptation of filling materials to root canal walls on stereomicroscopic photographs: Ratio of the areas not adapted to the canal walls (the periphery of non-adapted areas) to the total periphery of cross-sections at 3, 6 and 9 mm distances from the endpoint was calculated and reported as percentage.
- The percentage of non-adapted areas to the total area of canal cross-section at the mentioned three levels was also calculated.

Statistical analysis

Two-way ANOVA was used to compare the mean percentages of void areas in different obturation techniques and type of specimens (acrylic blocks and teeth).

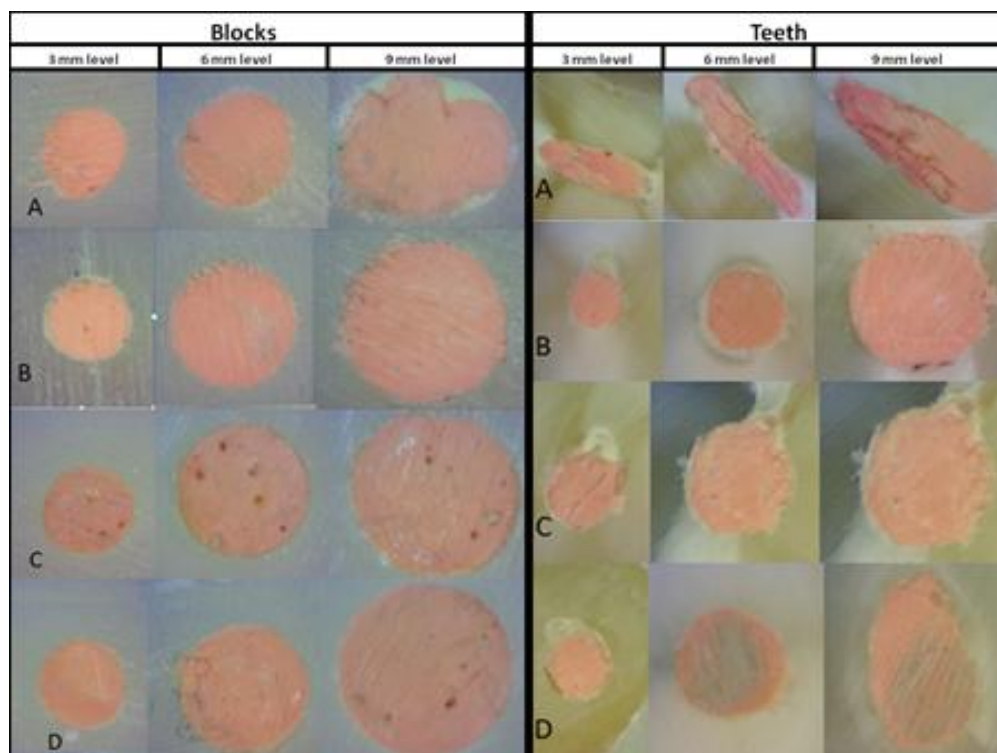


Fig 2. Cross sections of canals in acrylic blocks filled with (A) LC (B) WVC (C) CWC and (D) MCWC techniques at 3, 6 and 9 mm distances from the endpoint.

Because of the significant interaction effect of these variables (obturation technique and type of specimens), one-way ANOVA was used for the comparison of techniques. Tukey's post hoc HSD test was applied whenever necessary. Independent sample t test was applied for comparison of specimens. Considering the abnormal distribution of data, nonparametric Kruskal-Wallis test and for pairwise comparison, Dunn test were applied to find differences in the mean percentages of non-adapted areas to the root canal walls and their peripheries.

The obturation time differences were analyzed using two-way ANOVA. Statistical analysis of the data was carried out using SPSS version 20. P values less than 0.05 were considered significant.

RESULTS

Adaptation to root canal walls

In teeth group, sections studied under the stereomicroscope showed no statistically significant

difference among the obturation techniques ($P = 0.139$). In root canals artificially created in blocks, LC technique had significantly higher percentage of non-adapted areas compared to MCWC at 3, 6 and 9 mm distances from the endpoint ($P = 0.02$). At 6 mm distance, LC group had significantly higher percentage of non-adapted areas compared to CWC ($P=0.003$) (Table 1). The three warm compaction techniques showed no statistically significant difference in adaptation to root canal walls in teeth and blocks ($P>0.05$).

Void area

The void area was significantly higher in the LC technique ($P< 0.001$) than in the other techniques in teeth. But other warm compaction techniques did not have statistically significant differences ($P >0.05$). No statistically significant difference was found among the four techniques in artificially created root canals in blocks ($P = 0.410$) (Table 2).

Table 1. The mean percentage of non-adapted areas and peripheries in stereomicroscopic evaluation

| % Mean(\pm SD) | | Periphery of non-adapted areas at 3mm distance | | Periphery of non-adapted areas at 6mm distance | | Periphery of non-adapted areas at 9mm distance | |
|-------------------|-------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|
| | | Non-adapted areas at 3mm distance | Periphery of non-adapted areas at 3mm distance | Non-adapted areas at 6mm distance | Periphery of non-adapted areas at 6mm distance | Non-adapted areas at 9mm distance | Periphery of non-adapted areas at 9mm distance |
| Group | | | | | | | |
| Teeth | Lateral compaction | 0.32(1.07) | 2.10(5.20) | 0.70(1.27) | 4.59(5.85) | 0.38(0.62) | 4.15(5.65) |
| | vertical compaction | 0.60(2.10) | 2.74(7.79) | 0.17(0.39) | 1.65(3.29) | 0.10(0.24) | 1.45(3.05) |
| | Continuous wave compaction | 0.00(0.00) | 0.00(0.00) | 2.37(7.36) | 5.92(14.24) | 0.85(2.23) | 4.93(12.77) |
| | Modified continuous wave compaction | 0.78(1.97) | 4.20(10.01) | 0.19(0.44) | 2.47(5.03) | 0.76(1.89) | 6.01(14.85) |
| Blocks | Lateral compaction | 0.50(0.86) | 3.50(5.06) | 1.01(2.17) | 5.63(10.56) | 0.11(0.16) | 1.91(2.64) |
| | vertical compaction | 0.90(2.49) | 3.35(9.17) | 0.27(0.74) | 2.60(5.97) | 0.37(0.70) | 4.62(8.46) |
| | Continuous wave compaction | 0.088(0.35) | 0.50(2.03) | 0.00(0.00) | 0.00(0.00) | 0.091(0.27) | 0.49(1.39) |
| | Modified continuous wave compaction | 0.00(0.00) | 0.00(0.00) | 0.010(0.042) | 0.10(0.42) | 0.00(0.00) | 0.00(0.00) |

Table 2. The mean percentage of void areas in root canal fillings in radiographic evaluation

| Groups | Teeth | | | | Block | | | |
|-------------------|--------------------|---------------------|----------------------------|-------------------------------------|--------------------|---------------------|----------------------------|-------------------------------------|
| | Lateral compaction | vertical compaction | Continuous wave compaction | Modified continuous wave compaction | Lateral compaction | vertical compaction | Continuous wave compaction | Modified continuous wave compaction |
| % Mean(\pm SD) | | | | | | | | |
| Void area | 7.59(5.63) | 0.82(1.19) | 0.93(1.16) | 1.10(2.61) | 2.94(1.83) | 1.65(1.29) | 1.70(2.80) | 2.13(1.64) |

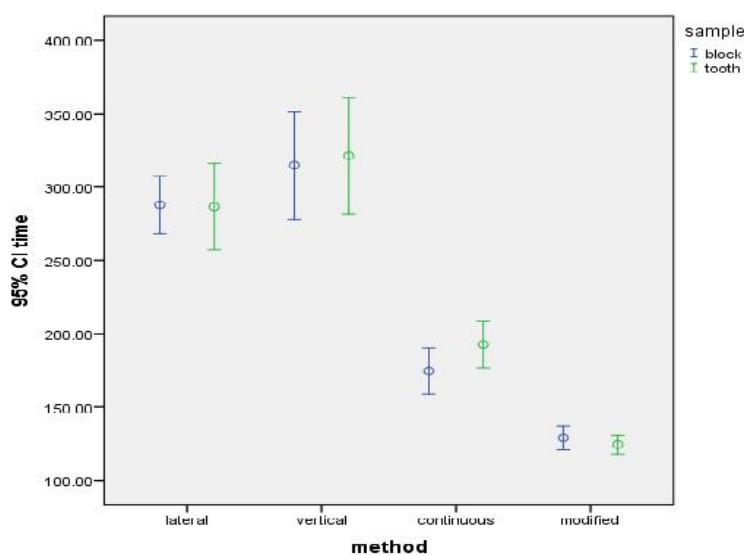


Fig 3. The obturation times

Obturation time

A statistically significant difference was found among the four techniques in root canals in teeth and blocks ($P > 0.05$). The longest obturation time belonged to WVC technique followed by LC, CWC and MCWC techniques. The difference between artificially created root canals in blocks and teeth was not significant ($P = 0.565$). The mean times of root canal obturation for the four techniques are shown in Figure 3.

DISCUSSION

Root canal filling is performed to inhibit the reentry and growth of bacteria. Many techniques have been introduced to serve this purpose. In this study, the quality of four obturation techniques was compared.

Today, LC technique is probably the most commonly practiced obturation method [20]. WVC is a classic thermoplastic method to produce a homogenous mass of gutta percha and CWC is a variation of this technique introduced to simplify the traditional WVC method [13].

The fourth technique is the MCWC that facilitates the packing of gutta percha.

Digital radiographs are more accurate for detection of voids compared to conventional radiographs [21]; thus, in this study, digital radiographs of all canals were taken in mesiodistal (proximal) plane to assess the presence of voids and evaluate the obturation quality.

Proximal radiographs can more accurately show the quality of gutta percha compaction and adaptation [22].

Because of the fact that buccolingual width of teeth is usually greater than their proximal width, this plane has more material to absorb the X-ray from the other plane resulting in masking of voids. However, for more accurate assessment of clinical cases, radiographs of filled canals should be taken in two planes: buccally and proximally.

In this study, the extracted human teeth were used to simulate the clinical setting. The inclusion criteria for the teeth were having a single root and only one straight or curved canal. The specimens were matched with regard to length and radius of the curve in the teeth group.

The other group was the acrylic block group.

These transparent blocks were used to decrease variations in root canal anatomies and to eliminate the confounding effect of opaque structures (cementum and dentin) covering the root canals. A disadvantage of using artificially created canals in blocks is that structure and composition of acrylic block canal walls are different from those of dentinal canal walls, and consequently, gutta-percha, sealers and other root canal filling materials would have different effects on them [7]. On the other hand, use of hot plugger can deform the canal wall in acrylic blocks [18]. However, in this study, no visible sign of deformation or discoloration of the acrylic blocks was seen.

In teeth, the opacity of dentin and cementum can somehow mask the voids. But, in acrylic blocks, these opaque tissues do not exist and detection of voids may be easier.

In the current study, the voids and adaptation to root canal walls were investigated radiographically. The sections were evaluated under a stereomicroscope. Evaluation was done after initial obturation of each canal without any correction. However, in the clinical setting, voids may be corrected, depending on their position, size and distance from the apex. In the current study, AH Plus sealer was used. This sealer is appropriate for warm compaction procedures because it is heat tolerant and that its setting reaction is not influenced by thermoplastic obturation techniques [23, 24].

This study demonstrated that LC caused higher areas of voids in teeth group. This result was in agreement with that of some previous studies [8, 25, 26]. But, in block group, no statistically significant difference was found among the four techniques. Such difference in results between the root canals of teeth and those created in blocks is probably due to irregularities in natural teeth. The clear acrylic blocks simplify direct visualization of gaps between the cones in LC technique. In WVC techniques, it seems that the voids are the consequence of air trapped in-between the increments of filling materials.

But, in the LC technique, the voids were seen between accessory cones because they did not fully occupy the space created by the spreader [20].

The current study does not attempt to extrapolate these findings to the clinical setting in areas like the quality of seal or success of outcome. The results of the current study indicated better adaptation of gutta percha to the canal walls in MCWC rather than LC technique in all sections of artificially created root canals in blocks. But, in teeth, this difference was not significant. No significant difference was found between warm vertical compaction techniques. Most previous studies suggest that WVC techniques can replicate the root canal anatomy better than the LC technique [8, 10, 27]. In these studies, the quality of filling of artificially created defects and lateral canals was assessed. Thus, method of investigation can be responsible for such controversy in results. With regard to the time taken to fill the canals using different techniques, the results showed that WVC took a significantly longer time than the other techniques.

This finding was in agreement with the result of a previous study [28] whereas; other researchers [7, 29] indicated that the LC technique was more time-consuming than WVC. However, the clinician's clinical skills and knowledge can influence the obturation time. As expected, the shortest obturation time belonged to MCWC. This can be attributed to the application of system B and simple process of packing without removing the coronally located filling materials from the canal walls after down packing.

CONCLUSION

Within the limitations of this in vitro study, MCWC technique is a simple and acceptable method providing better adaptation of gutta percha and sealer to the entire canal walls (compared to LC) with fewer voids at a faster time compared to other techniques investigated in this study. In vivo studies are needed

to confirm these results and assess the outcome of treatment using these techniques.

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