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Enhancing Coronal Adaptation of Root Canal Fillings with a Modified Single-Cone Obturation Technique: Two Case Reports

Mahmood Reza Kalantar Motamedi [a], Brett E. Gilbert [b], William N Ha [c*]

a Dental Research Center, Dental Research Institute, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran; b Department of Endodontics, College of Dentistry, University of Illinois at Chicago, Chicago, IL, USA; c The University of Sydney, Faculty of Medicine and Health, Sydney Dental School, Australia

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****Corresponding author***: William N Ha, The University of Sydney, Faculty of Medicine and Health, Sydney Dental School, Australia.

E-mail: william.ha@sydney.edu.au

The single-cone technique, also known as the hydraulic condensation technique, is widely employed in endodontics. However, the aforementioned method is presented with certain limitations; specifically concerning the coronal seal and the adaptation of the coronal third of a master gutta-percha (GP) with a round cross-section to the coronal dentinal walls of root canals with semi-round or oval cross-sections. Through two case reports, the current article introduces the coronal vertical condensation (CVC) technique; aiming to enhance GP adaptation to canal walls in similar scenarios. In fact, the coronal vertical condensation technique amalgamates the different aspects of warm vertical condensation and single-cone techniques. In CVC, following the placement of the master GP cone, an electrical heat carrier is inserted immediately a few millimeters apical from the canal orifice to remove the coronal portion of the master GP cone. Subsequently, a hand plugger is used to condense GP in the vertical dimension, and the coronal space is backfilled using melted GP. The implementation of CVC technique has demonstrated an improved coronal adaptation of GP with canal walls. The stated technique seems beneficial; especially in the obturation of severely curved canals or root canals with a final preparation shape of variable taper.

Keywords: Root Canal Filling Materials, Root Canal Obturation, Root Canal Preparation, Root Canal Therapy

Introduction

Coronal leakage can be a cause of endodontic treatment failure [1]. Therefore, clinicians must do their best to develop a reliable coronal seal for endodontically treated teeth. With the improvement in bioceramic sealers' physical and chemical properties, the popularity of the single-cone (SC) technique, also known as the hydraulic condensation technique [2], has increased [3]. However, this technique might have some limitations, especially regarding the coronal seal [4].

Voids and other minor defects in the obturation, which often cannot be detected radiographically, may contribute to rapid recontamination of the root canal system [5]. Laboratory studies have shown that in the SC technique, the majority of the voids are present in the coronal third [6-8]. Iglecias *et al.* [7] reported in their microcomputed tomography study that the SC technique yields similar obturation quality except in the coronal third compared to the warm vertical condensation (WVC) in curved canals, where WVC had a better filling quality in terms of voids.

When using the SC technique, the sealer volume consistently increases from the apical to the coronal part [9]. Monticelli *et al.* [4] discovered that the WVC technique is more effective in reducing bacterial leakage than the SC technique. The reduced bacterial leakage of the WVC can be attributed to the reduced sealer thickness compared to the SC technique [4, 10]. The WVC technique creates a thinner layer of sealer and a higher proportion of gutta-percha (GP) than the SC technique, in the middle and coronal thirds of the canals [10]. Despite advancements in SC technique with the use of greater taper master cones that match the geometry of nickel-titanium rotary instruments, a larger proportion of sealer is still expected due to the presence of canal fins, anastomoses, cul-de-sacs, and oval-shaped canals [11].

Figure 1. *A*) Preoperative radiograph; *B*) working length radiograph; *C*) postoperative radiograph; *D*) two-year follow-up radiograph

Vertucci reported that 23% of lateral canals extend from the coronal third to the furcation region [12]. Consequently, periodontal disease progression can lead to exposure and bacterial contamination of the accessory canals, more frequently in the apical third of the root and at the furcation [13].

Therefore, establishing a good seal with a well-fitted obturation from the coronal to the apical portion of a chemomechanically prepared root canal will help prevent bacterial reinfection [14].

When utilizing the SC technique, the preparation shape should match the size of the master apical file [15]. However, most root canals do not have completely round cross sections, especially in their coronal third [16, 17]. Ingle described the canal's shape as ovoid at the coronal third, round or ovoid at the mid-root third, and round in the apical third [16]. Baisden et al. [17] reported a predominant oval canal shape at the coronal level that tapers to a round canal shape in the apical portion. A master GP cone with a round cross-section would have less adaptation in the coronal portion compared to the middle and apical levels. Moreover, in a root with two or more canals, there can be various interconnections, such as isthmi, predominantly seen in the coronal and middle thirds of the canals [18]. As such, a single GP cone matched to the final taper of the prepared root canal cannot create a good adaptation in such areas.

The matched-taper SC technique has been advocated for the obturation of curved root canals [19]. Managing severely curved or double-curved (S-shaped) canals can be challenging during root canal preparation, leading to an increased risk of procedural errors [20]. As the curvature's angle increases and the radius decreases, the instrumentation difficulties for a curved canal trajectory become significantly more challenging [20]. Common errors during this process include transportation, ledges, perforations, and instrument separation [21]. In addition, these procedural errors may decrease the prognosis by reducing the clinician's ability to eliminate intracanal infection [22].

In general, to prepare severely curved canals, enlarging the coronal part up to the beginning of the curvature before addressing the curvature is recommended [23]. For S-shaped canals, the first curvature should be prepared before addressing the second curvature [23]. Instruments with larger tapers can be used for this purpose, while the apical portion can be prepared with instruments with smaller tapers. Some clinicians prefer using a combination of rotary files from various systems to overcome the curvature; this is known as a hybrid approach [24]. Coronal flaring can potentially prepare the canal beyond the confines of the shaping dimensions of the finishing file, particularly when larger tapers or deeper insertion depths of coronal flaring instruments have been used [25]. Nevertheless, coronal flaring beyond the shaping dimensions of the finishing file reduces the contact along the coronal portions of the root canal, thus reducing the stresses on the file, which can help negotiate severely curved canals [26]. However, if the GP cone matching the final finishing file was used, the GP would have coronal discrepancy as the coronal flaring is wider than the matching cone [27]. Hybrid techniques that combine different tapers or variable tapers of different systems may create a final preparation shape of variable tapers. As a result, the final preparation shape would not match any commercially available GP cone, thus reducing the fit of the master cone when using SC technique.

In these case reports, we propose a modified technique for enhancing the coronal adaptation of root canal obturations using the SC obturation technique. By combining the WVC and SC techniques, this technique adapts the GP to the coronal geometry of the prepared root canals. We call this technique coronal vertical condensation (CVC), and describe it in detail in the following case reports.

Case report 1

A 22-year-old female presented with symptomatic irreversible pulpitis. Radiographic examination revealed deep caries in the crown of tooth #13, extending to the pulp chamber of a dilacerated S-shaped root canal. Periapical tissues appeared normal (Figure 1A).

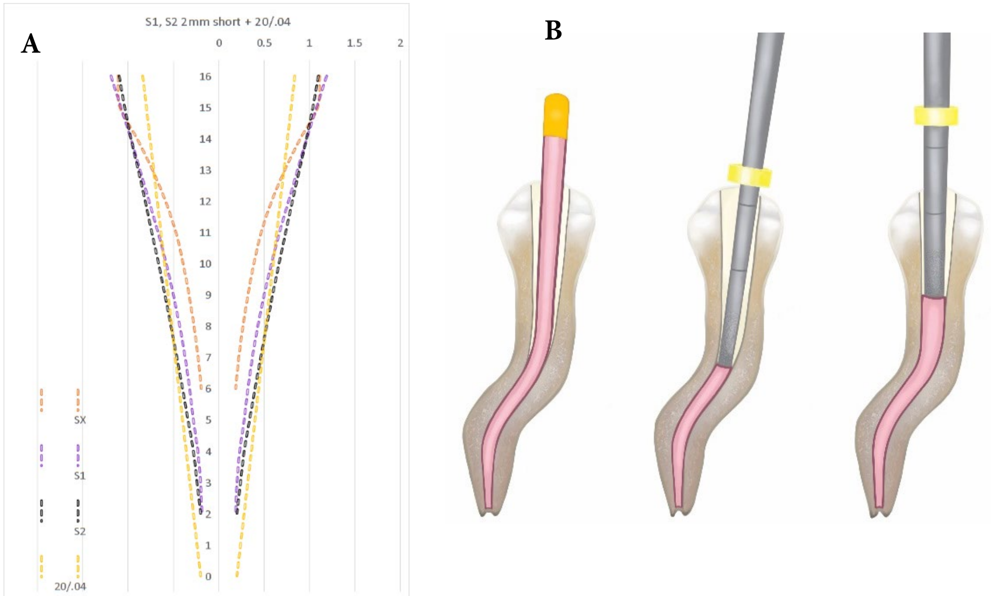

Figure 2. *A*) Geometry of the canal after hybrid instrumentation; *B*) Coronal vertical condensation technique to enhance the adaptation of the coronal root filling

After administering infiltration local anesthesia with 1.8 mL of 2% lidocaine with 1:100,000 epinephrine (Novocol Pharmaceutical Inc, Cambridge, Canada), the tooth was isolated with a dental dam. The mesial carious lesion was removed, and a straight-line access cavity was prepared. Throughout the procedure, the irrigant of choice was 5% sodium hypochlorite. Canal negotiation was first completed by using #08 and #10 K-files (Mani, Tochigi, Japan) to the first curvature. Then, a crown-down approach was utilized with SX for coronal enlargement and S1 and S2 (Protaper Gold, Dentsply Maillefer, Baillagues, Switzerland) to reach the first curvature. Again, #8 and #10 K-files were introduced and could travel further in the canals through the second curvature. A control radiograph was taken (Figure 1B).

Afterwards, an S2 rotary file was used repeatedly to reach the level of the second curvature, and then the #10 K-file could reach the full length. At this stage, for preparation of the apical portion beyond the second curvature, we switched to constant taper rotary files. The 17/.04 and 20/.04 (T-pro, Shenzhen Perfect Medical Instruments Co. Ltd., Guangdong, China) rotary files were used to the full length.

After manual agitation of sodium hypochlorite, canals were rinsed with saline and dried using sterile paper points. Master GP cones (Meta Biomed, Cheongju, South Korea) of 20/.04 were fitted. The tips of the cones were coated with AH26 sealer (Dentsply DeTrey, Konstanz, Germany), and they were fitted to full length.

At this stage, the CVC obturation technique was performed. Since the canals were enlarged up to the level of the first curvature using SX to S2, the coronal part of the master GP cone, which has a 4% taper, cannot fit well to the coronal canal wall (Figure 2A).

The tip of the electrical heat carrier (Fast-pack, Eighteeth, Changzhou, China) was inserted up to the level of the first curvature. The coronal portion of the master cone was removed, leaving the remaining part to be packed with a nickel-titanium hand plugger. The coronal space was backfilled using melted GP (Fast-fill, Eighteeth) and packed 1 mm below the level of orifices. (Figure 2B) schematically depicts the procedure of the CVC technique. Then, the tooth was temporized and returned to the referring dentist for permanent restoration (Figure 1C).The patient was asymptomatic at the two-year follow-up, with a radiograph examination showing a normal periapical appearance (Figure 1D).

Case report 2

A 57-year-old female patient presented with pulpal necrosis and chronic apical abscess on tooth #19. She was aware of a long-standing sinus tract on her buccal gingiva that had been present for one month and was not resolving. Anatomically, this tooth presented with severely curved root morphology. Radiographically, the tooth presented with a mesial root periapical lesion that extended from a partially resorbed mesial apex coronally along the distal surface of the mesial root into the furcation (Figure 3A). The distal root presented with a large periapical lesion that extended distally to the mesial apex of tooth #18.

***Figure 3**. A) Preoperative radiograph; B) postoperative radiograph; C) 26-month follow-up radiograph*

After administering an inferior alveolar block on the left side with 3.6 mL of 2% lidocaine with 1:100,000 epinephrine (Patterson Dental, St. Paul, Minnesota, USA), the tooth was isolated with a dental dam. The tooth was accessed, and the occlusal amalgam was removed, leaving only a lingual pit amalgam in place. Access to three canals, the mesiobuccal, mesiolingual, and distal, was achieved. Triton (Brasseler USA, Savannah, GA, USA) was used as the primary irrigation solution throughout the procedure. Canal negotiation was initially carried out with #8 and #10 carbon steel hand files (Stiff Files,Brasseler USA) to the first curvature. The hand files progressed beyond the curves using a watch winding motion to create an initial glide path. The coronal orifices were opened using an orifice modifier size 20/v.08 (Trunatomy, Dentsply Sirona, Charlotte, NC, USA). Canals were measured using an electronic apex locator (ApexID, Kerr Endodontics, Brea, CA, USA). The three canals were instrumented using a rotary glide path file size 17/v.02 (Trunatomy, Dentsply Sirona) to the full measured working length. Apical enlargement in the mesiobuccal and mesiolingual canals was accomplished with Trunatomy 20/v.04 and 26/v.04 files. The distal canal was prepared using the same sequence ending with a 36/v.03 file. Sonic activation (EQ-S, Meta Biomed) of the Triton solution was done for three 20-second intervals in each canal using fresh Triton solution in each canal for each interval. Canals received a final irrigation of Triton solution and were dried with sterile paper points. Master GP cones (Dentsply Sirona) of 25/v.04 for mesiobuccal and mesiolingual canals and 36/v.03 for distal canal were selected.

Bioceramic sealer (BC HiFlow, Brasseler USA) was placed in the coronal third of the canals. Each GP cone was placed into the canal using slow movement to full working length. The CVC obturation technique was employed using a heated electrical heat carrier (Elements IC Downpack Unit, Kerr Endodontics) placed a few millimeters below the orifice of each canal to separate the GP cone. A hand plugger was used to condense the GP in the vertical dimension. The coronal space was backfilled using melted GP (Element IC Backfill Unit, Kerr Endodontics). Resin ionomer (BC Liner, Brasseler USA) was placed over each canal orifice and the pulp chamber floor. Optibond universal (Kerr Endodontics) and Multicore Flow core material (Ivoclar, Schaan, Liechtenstein) were placed as the permanent coronal restoration for the subsequent crown preparation (Figure 3B).

A 26-month follow-up radiograph demonstrated significant healing of the periapical lesions around roots and the furcation. Evidence of the periapical lesions on both roots remained visible but were significantly smaller (Figure 3C). The patient no longer had a sinus tract present and has been asymptomatic for the entire follow-up period.

Discussion

The CVC technique was used in these cases to overcome the limitations of the SC technique in terms of coronal adaptation of the GP cone. By using the CVC technique, a better adaptation of the GP with canal walls was achieved compared to performing the SC alone.

The CVC technique was fast and only contained one additional step compared to the SC technique. Also, vertical length control of the obturation was easy because the penetration length of the heat carrier was limited in this technique. A meta-analysis by Peng *et al.* [28] found that the WVC technique has a higher rate of overextension than SC technique. The CVC technique has a shallower compaction depth that falls between SC and WVC. Therefore, the risk of extrusion with CVC would be less than WVC.

The CVC technique might be beneficial when using some bioceramic sealers that are sensitive to heat because the heat carrier is not inserted beyond the coronal third. Hence, the heat does not affect the remaining GP and sealer in the apical third. As such, there is no concern regarding the chemical or physical changes of the sealer in the apical third and, consequently, apical seal deterioration. Moreover, cutting the coronal GP is easy and can also be done with lower temperatures of the heat carrier. There might also be a lower risk of periodontal ligament damage from overheating as less heat is required and the heat carrier remains in the canal for a shorter amount of time [29]. During the continuous-wave condensation technique, a significant temperature rise of more than 10 °C was reported when the activation time of the heated plugger was increased to 4 seconds, with the greatest temperature rise located at the danger zone of the mandibular first molar [30]. Another advantage of the CVC technique is that a constant taper GP could be used in a variable taper preparation to create a better coronal fit. CVC is a valuable technique when no matching GP cone is available.

A limitation of this technique is that laboratory studies and clinical trials are lacking. Nevertheless, it would be logical that the properties of the technique would fall between SC and WVC.

De Figueiredo *et al.* [31], in their randomized controlled clinical trial, reported that for treating anterior teeth with apical periodontitis, SC obturation was as effective as the traditional lateral compaction obturation technique regarding periapical healing. Chybowski *et al.* [32] reported in their retrospective clinical study that the overall success rate of nonsurgical root canal treatment using SC and a bioceramic sealer is 91%. Iglecias *et al.* [7] showed that SC and continuous-wave condensation obturation techniques are similarly efficient in filling the root canal space. However, they stated that continuous-wave condensation performed better in the coronal part of the obturation in regard of minimizing voids [18]. The CVC technique we introduced in this article might combine the advantages of SC and continuous-wave condensation; however, further well-designed clinical studies are necessary to compare SC and warm GP techniques [33].

Conclusions

The authors do not think this technique is necessary if the GP matches the final shape of the canal. Also, we do not yet suggest this technique for the obturation of canals with many irregularities, such as c-shaped or figure-of-eight root canals. However, the CVC technique is worth considering when there is notable coronal flaring when canals are prepared with crown-down or hybrid techniques. Moreover, the CVC technique is helpful in severely curved root canals when the tip of the heat carrier cannot travel beyond the curvature. It might also be practical for the obturation of conservatively shaped root canals. The authors suspect many clinicians already perform CVC; however, this technique has not been described in any academic writing. The CVC technique should improve the adaptation of GP to canal walls compared to the SC technique, with ex vivo research required for validation. Similarly, the CVC technique should have reduced extrusion compared to the WVC technique, which also requires validation, whether with ex vivo or clinical studies.

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Conflict of interest
None.

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Authors' contributions
Mahmood Reza Kalantar Motamedi: Conceptualization, Methodology, Validation, Writing-Original Draft. Brett E. Gilbert: Methodology, Validation, Writing-Original Draft. William N Ha: Methodology, Supervision, Project administration, Writing-Review & Editing

Informed consent:
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