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Thermoplastic Obturation of Flattened Canals with Ultrasonic Vertical Condensation: A Microtomographic Analysis

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Research Article

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ABSTRACT

Objective: To evaluate the obturation quality of mandibular molars flattened distal canals using ultrasonic certical condensatio (UVC) compared to the Continuous Wave of Condensation (CWC) technique through micro-Computed Tomographic (micro-CT) assessment.

Methods: Mandibular molars were micro-CT scanned for sample homogenization, and the volume and flattening (B-L/M-D>4) of the distal canals were determined. Thirty-six canals were then prepared with protaper gold instruments up to #F3 associated with 2.5% sodium hypochlorite, followed by passive ultrasonic irrigation. After instrumentation, the canal volume was determined in a new scan, and the roots were randomly divided and allocated to UVC and CWC groups. Fourteen days after obturation with gutta-percha and AH plus sealer, the specimens were scanned again to evaluate the filling quality.

Results: None of the fillings performed completely filled the canal area. Obturation values of 83.33% (UVC) and 89.97% (CWC) were observed; the Student's t-test exhibited no significant difference between the techniques (P>0.05).

Conclusion: Under the conditions of this study, it was observed that none of the evaluated techniques was able to completely obturate the canals; nevertheless, UVC achieved similar results compared to the CWC technique.

Clinical relevance: Despite not being able to completely obturate the complex root canal anatomy, both techniques yielded satisfactory fillings. Ultrasonic vertical condensation could be an interesting clinical option for filling flattened canals, achieving a similar outcome to that of the continuous wave of condensation technique.

Keywords: Endodontics; Canal system obturation; Flattened canals; Thermoplasticization; Ultrasonic vertical condensation.

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INTRODUCTION

The meticulous chemical mechanical preparation associated with a subsequent three-dimensional filling of the root canal is a key aspect of the long-term success of endodontic treatment. However, some variables such as the lack of adhesion between the filling material and the dentin and the complexity of the internal anatomy of the root may hinder the homogenous obturation of spaces previously occupied by the pulp [1].

In this perspective, several root canal filling techniques aiming at the complete and uniform sealing of the canals have been proposed [2]. Among these, thermoplastic techniques stand out for the possibility of filling ramifications and anatomical irregularities, in addition to providing fillings with less use of sealing materials, which, should be used the least amount possible [3].

Moreover, thermoplastic techniques, notably the Continuous Wave of Condensation (CWC), have been suggested among the newest and most effective solutions for clinical situations related to the obturation of flattened and oval canals. Alternatively, some authors have advocated for the use of Ultrasonic Vertical Condensation (UVC) [4]. This approach enables the thermoplasticization of the filling material by transferring the thermomechanical energy produced by ultrasound to the gutta-percha cone, as well as enhancing the penetration of the sealer into the dentinal tubules. For this, Helse Ultrasonics (Santa Rosa do Viterbo, SP, Brazil) has developed two ultrasonic tips, the cutcondense, similar to a condenser used to cut cervical excess gutta-percha, and the thermosonic, which has a shank of 14 mm (Ø 0.33 mm) with an inverted cone of 1.5 mm at its end (final Ø 0.73 mm) [5]. As it is configured, according to the manufacturer, it provides a filling that incorporates indirect activation and short-range vertical hot compaction [6].

Despite continuous research focusing on the improvement of obturation techniques, comparative studies on the quality of root canal filling provided by these techniques are still scarce, albeit necessary [7]. Thus, the aim of the present study was to evaluate the filling quality (amount of sealing material and the presence of voids) in flattened distal canals of lower molars obturated using UVC compared to CWC assessed through micro-Computed Tomography (micro-CT). Null hypothesis tested was that the thermoplastic technique with the UVC proportion the same quality of filling that the CWC [8].

MATERIALS AND METHODS

Sample size calculation

The sample size was determined using the G*Power 3.1.7 software (Heinrich Heine, Universitat Dusseldorf, Germany). Based on a previous study by Santos-Junior et al., considering an alpha error of 0.05 and a beta power of 0.8, a sample size of 18 specimens was estimated as necessary. However, considering the possibility of specimen loss during the study, the final number was set at 20 specimens per study group [9].

Sample selection and preparation

For this study, 40 flattened distal roots of mandibular molars were used. After approval by the local research ethics committee (5,129,166), the teeth were collected through donation after being extracted for reasons unrelated to the study. Once the final sample number was reached, the external surface of the specimens was cleaned and their internal anatomy was initially evaluated through images captured by a digital radiographic sensor (FIT; Micro Imagem, Indaiatuba, SP, Brazil). The images were screened for the presence of a single canal in the distal root and its configuration [10].

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Micro-CT scanning

After initial radiographic analysis, the teeth were scanned with a micro-CT device (SkySan #1174; Bruker-microCT, Kontich, Belgium) to determine the anatomical characteristics, volume measurements, and flattening pattern, as well as to standardize the sample so that the canals were randomly divided between the experimental groups [11].

Before image capture, the teeth were adapted to wax blocks and individually coupled to a metal base attached to a rotating table, which enabled a perpendicular positioning in relation to the radiation source during the scanning process; the voltage was set at 50 kV and 800 µA, and a detector based on a special 1.3-megapixel camera was used [12]. The scanning resulted in a series of radiographic images captured at different angles every 0.7°, totaling a 180° rotation; the generated images were stored in TIFF format. After image acquisition, three-dimensional reconstructions in different angular projections using the modified Feldkamp cone beam reconstruction algorithm were performed with the NRecon software (Bruker-microCT), in which a 3D model of the root canal was created with the "create 3D model" tool. The same acquisition sequence was repeated on all subsequent scans [13].

Only root canals with a length between 19 and 21 mm, curvature angle below 20º, and flattened anatomy (buccal-lingual/mesio-distal (B-L/ M-D) ratio ≥4) were included in this study [14].

Specimen preparation

Once the anatomy of the canals was confirmed, cavity access was performed with #1014 and #1015 round diamond burs (KG Sorensen, Sao Paulo, SP, Brazil) at high-speed rotation under abundant irrigation [15]. To finish the access cavity, diamond burs #3082 (KG Sorensen) were also used at high-speed rotation under cooling. The canals were then irrigated with 2.5% sodium hypochlorite, and the initial probing was carried out with #08 and #10 K-type hand files (Dentsply-Sirona; Ballaigues, Switzerland) until their tips were visualized through the apical foramen [16]. Sequentially, the same procedure was performed with #15 and #20 K-files. These steps were performed using a clinical microscope (MC-M12; DF Vasconcellos, Valença, RJ, Brazil) with an eight-fold magnification to facilitate visualization. During this procedure, the apical patency was confirmed, and the Real Canal Length (RCL) was determined [17].

The Working Length (WL) was obtained by subtracting 1.0 mm from the RCL. After WL determination, specimens were prepared by a single trained operator using a Silver Reciproc motor (VDW GmbH, Munich, Germany) coupled to a 6:1 contra-angle (Sirona, Bensheim, Germany) and Protaper Gold instruments from #SX to #F3 (PTG; Dentsply-Maillefer; Ballaigues, Switzerland). The instruments were used in continuous rotation at 300 RPM and 520 g.cm torque for the coronal and middle third preparation, and 150 g.cm for the apical third, as recommended by the manufacturer. During the preparation, a #20 K-file was used between each instrument change to keep the foramen unobstructed, with the RCL set as the apical insertion limit [18]. At each instrument change, 2.5 mL of 2.5% sodium hypochlorite (Asfer Indústria Química LTDA, Sao Caetano do Sul, SP, Brazil) in a 5.0 mL syringe with a 30G irrigation needle (Endo-Eze NaviTip; Ultradent, Indaiatuba, SP, Brazil) were used as irrigating solution. The apical irrigation limit was established at 2.0 mm short of the WL.

Additionally, a complementary coronal preparation was carried out using brushing movements in the M-D and B-L directions of the distal canals according to the anatomy of the canals; the same instrument employed in the preparation procedure was used, this time limited to 5.0 mm short of the WL. After chemo-mechanical preparation, the canals were submitted to final irrigation with 5.0 mL saline solution, followed by aspiration and drying with absorbent paper points.

Canal obturation

During sample preparation, four specimens were lost; the others were divided into 2 groups (n=18) according to the

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obturation technique used (CWC or UVC). Regardless of the experimental group, the fillings were performed using gutta-percha cones compatible with the last instrument used and fitted to the WLs. The canals were irrigated with 17% ethylenediaminetetraacetic acid for three minutes and submitted to a final wash with 5.0 mL saline solution. After aspiration and drying with absorbent paper points, the AH Plus sealer (Dentsply-Sirona, York, Pennsylvania, USA) was mixed and inserted with the cone in the previously established position.

The randomization of the specimens considering the anatomical characteristics and the canal volume was then performed. Once the cones were fitted, hot vertical condensation was carried out using a heated plugger (Fast Pack; MK Life Medical and Dental Products, Porto Alegre, RS, Brazil) set at 200ºC; the plugger was inserted 3 to 4 mm short of the WL. The equipment was then turned off and kept inside the canal for 10 s under apical compression. The heating was then reactivated, which enabled the removal of the tip and excess filling material. Cold Schilder pluggers (Odous de Deus, Belo Horizonte, MG, Brazil) were used with apical pressure to conclude the down-pack. The middle and coronal thirds of the canals were filled with an automatic obturation gun (fast fill; MK life medical and dental products), which facilitated the insertion of softened gutta-percha into the anatomical spaces left after the first phase of the technique. Small increments of the material were manually inserted and condensed with cold schilder pluggers.

For the UVC group, after the gutta-percha cone was cemented, two ultrasonic tips were used, in sequence, driven by a piezoelectric ultrasound device (ultrawave XS; ultradent products, USA, utah) set at 30% power. Initially, a CutCondenser tip (Helse Ultrasonics, Santa Rosa do Viterbo, SP, Brazil) was used to cut the gutta-percha at the canal orifice. Then, a Thermosonic tip (helse ultrasonics), also at 30%, was inserted apically up to 3 to 4 mm short of the WL to plasticize the gutta-percha of the middle and apical thirds for 30 s. The tip was then removed from the canal, and vertical condensation of the softened gutta-percha was carried out with cold schilder pluggers.

Regardless of the experimental group, the specimens were sealed with glass ionomer cement and stored in a humidified oven at 37°C and 100% humidity until a new scan was performed.

Obturation analysis

Fifteen days after obturation, the specimens were scanned again in the micro-CT device using the same parameters previously applied. With the reconstructed post-obturation images, three-dimensional analyses of the filling achieved by the techniques were performed, and the percentage of void spaces was determined.

Statistical analysis

The Kolmogorov-Smirnov normality test indicated the parametric nature of the data. Then, the unpaired student's t-test was used, which enabled the comparison between the experimental groups; the level of significance was set at 5%.

RESULTS

It exhibits illustrative images of representative specimens of the two experimental groups. Mean and standard deviation values of the filling achieved by the obturation techniques are shown in Table 1. In general, the mean filling volumes were satisfactory, especially considering the anatomical difficulties encountered along the entire length of the flattened canals. Neither of the techniques was able to completely fill the volume of the canals, and the filling values did not reveal significant differences between the groups (P>0.05).

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Table 1. Mean and Standard Deviation (SD) values regarding root canal space filled with obturation material in both experimental groups (%).

Group	n	Mean	SD
CWC	18	89,97[a]	8,996
UVC	18	83,33[a]	11,28
[a,b] Similar superscript letters represent no statistical difference according to the student's t-test (P<0.05).			

DISCUSSION

Given the importance of the root canal filling step within endodontic therapy, the present study sought to evaluate the effectiveness of two thermoplastic obturation techniques in filling complex anatomies such as those presented in flattened canals. In the comparison performed in this study, UVC proved to be effective for the filling of flattened canals compared to the already established CWC technique, accept in the null hypothesis proposed.

Considering the complexity imposed by flattened roots, the present study used distal roots of mandibular molars that exhibited only one canal with this characteristic, which was based on a B-L/M-D ratio>4. These roots were instrumented up to PTG #F3, using brushing movements to achieve a close-to-ideal model, facilitating the subsequent filling of these canals, as previously demonstrated in the literature. At the time of filling, the sealer of choice for both groups was the AH Plus sealer because of its excellent properties, in addition to being one of the most used in studies of this nature.

Regarding the obturation quality, none of the evaluated techniques was able to completely obturate the distal canals. The results obtained by the CWC technique were consistent with the current literature, exhibiting values of approximately 90%. This observation reinforces the effectiveness of this method for the obturation of complex anatomies.

Conversely, despite the limited discussion concerning its use compared to the CWC technique, UVC demonstrated high efficacy, both for sealer distribution and gutta-percha plasticization. Our findings regarding the filling of flattened canals using UVC revealed an obturation efficiency of 83%, similar to that observed for other thermoplasticizing techniques.

The number of specimens and the comparison of only two obturation techniques were some of the limitations of this study. Nonetheless, it was possible to observe that both methods yielded satisfactory fillings despite the anatomical difficulties, albeit none of them was capable of completely filling the flattened canals. These findings highlight the possibility of employing UVC as a heat source for improving plasticization and distribution of gutta-percha during the obturation, being an option for thermoplastic devices, such as continuous wave of condensation technique, for performing thermoplastic filling techniques for flattened root canals. However, it is worth noting that more studies are needed, preferably with a similar design and investigating other variables, as well as long-term follow-up studies of the results initially accomplished.

CONCLUSION

Under the conditions of the present study, the use of thermomechanical energy produced by ultrasonic agitation was effective in thermoplasticizing gutta-percha, which resulted in root canal fillings similar to those achieved by the continuous wave of condensation technique.

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ETHICAL APPROVAL

This study was previously approved by Local Ethics Committee (#1.900.129/2017) and was in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

COMPETING INTEREST

The authors deny any competing interest related to this study.

AUTHOR'S CONTRIBUTION

Authors Caio CDO Carmo, N Vivacqua-Gomes, Rodrigo R Vivan, Marco AH Duarte and Bruno C Vasconcelos outlined the study; Authors Caio CDO Carmo, Pedro HS Calefi, Alinne PPO Feitosa, Murilo P Alcalde performed the research procedures; Authors Nilton Vivacqua-Gomes, Marco AH Duarte and Bruno C Vasconcelos performed the statistical analysis; Authors Pedro HS Calefi, Alinne PPO Feitosa and Murilo P Alcalde prepared bthe figure; All authors reviewed the manuscript.

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AVAILABILITY OF DATA AND MATERIALS

Not applicable.

INFORMED CONSENT

Informed consent was obtained from all individual participants included in the study.

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