Original Article

A Comparative Evaluation of Endodontically Treated Root Canals Obturated Using Gutta-percha with Two Different Protocols: An *In-vitro* Study

Arnaldo Munive-Degregori[1], Frank Mayta-Tovalino[2], Cecilia Lúcar-Flores[3], Roman Mendoza[1], Daniel Alvitez-Temoche[1], Carlos Guillen-Galarza[3]

[1]Postgraduate Department, Faculty of Dentistry, Universidad Nacional Federico Villarreal, Lima, Peru, [2]Postgraduate Department, CHANGE Research Working Group, Faculty of Health of Sciences, Universidad Científica del Sur, Lima, Peru, [3]Academic Department, Faculty of Dentistry, Universidad Nacional Mayor de San Marcos, Lima, Peru

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ABSTRACT

Objective: The aim of this article is to evaluate the quality of filling in endodontically treated root canals using the lateral condensation technique and modified lateral condensation technique. **Materials and Methods:** Thirty-two single-rooted teeth were divided into two groups that were assigned by simple randomization according to the filling technique. Once the endodontic treatment was performed, a periapical radiograph was taken to assess the quality according to the radiographic density and tomography was taken to evaluate the quality according to the tomographic volume of spaces, compared with the post-preparation biomechanical tomography. Finally, we performed a statistical analysis (Student's *t*-test) to evaluate whether there were differences between the types of filling. **Results:** Radiographic radiodensity was 182.89 ± 9.81 and 186.72 ± 6.97 HU for teeth treated with the lateral condensation technique and modified lateral condensation technique, respectively. The void volume was 3.75 ± 2.35 and 2.43 ± 1.18 mm^3 for teeth treated with the lateral condensation technique and modified lateral condensation technique, respectively. **Conclusion:** No significant differences were found between the techniques for both filling quality parameters.

Keywords: *Endodontics, filling techniques, in-vitro study, lateral condensation*

Introduction

Epidemiological studies have revealed a high prevalence of apical periodontitis in endodontically treated teeth.[1] This situation represents a healthcare problem as it can lead to medical, economic, and ethical consequences.[1,2] Consequently, it could be considered that the lack of technological equipment would be a determining factor for performing quality endodontic treatment; however, the literature shows that there are no statistically significant differences between performing the endodontic treatment using the lateral compaction technique when compared with thermoplastic canal obturation techniques.[3,4]

In this situation, it is important to propose improvements to the lateral compaction technique. These should contribute to improving the quality of the landfill without generating significant changes in the quantity of resources, guaranteeing a high-quality treatment. The quality of life of an individual can be influenced by different factors, one of which is the state of health, which can be affected by oral diseases. Currently, there is a high prevalence of oral diseases,

Address for correspondence: Dr. Frank Mayta-Tovalino, Postgraduate Department, CHANGE Research Working Group, Faculty of Health of Sciences, Universidad Científica del Sur, Av. Paseo de la República 5544, Miraflores, Lima 15074, Peru.
E-mail: fmaytat@cientifica.edu.pe

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particularly in vulnerable populations, which have limited access to health services. In the case of dental caries, if this deficit in access to health is not resolved in the early stage of the disease, a greater investment of resources will be required to terminate the disease, as is the case with endodontics.[1-5]

Technological advances in health have made it possible to improve and optimize procedures that comprise the endodontic treatment; however, these advances must be constantly corroborated, in addition to proposing continuous improvements, particularly if they ensure quality and accessibility.[6]

The endodontic treatment procedure begins with a combination of mechanical instrumentation and chemical debridement, after which the worked canal is filled with a biocompatible material to maintain or restore the health of the periapical tissue. This last step, known as obturation, is the result of endodontic treatment; therefore, evaluating the quality of the filling will be an indicator to evaluate endodontic treatment.[7,8]

Therefore, this study aimed to evaluate the radiodensity and tomographic volume of root canals treated endodontically with gutta-percha using two different protocols.

Materials and Methods

Study design and sample size

This study was conducted *in vitro*. The analysis unit was made up of measurements from cone beam-type computed tomography (CT) taken from the endodontically treated pieces that were assigned by simple randomization according to the filling technique. The distribution of the groups was as follows. The calculation of the sample size was performed using the formula for comparing two means using the Stata® version 15 program with an alpha of 0.05 and a beta of 0.8, resulting in the need for $n = 16$ specimens per group. Finally, the checklist for reporting *in-vitro* studies CRIS guidelines was used to prepare this manuscript.

Allocation

The following groups were formed:

Group 1: Teeth treated endodontically using the lateral condensation technique.

Group 2: Teeth treated endodontically using the modified lateral condensation technique.

Preparation of specimens

Upper and lower premolars were extracted for orthodontic reasons beyond the objective of this study. The root canal treatment for each tooth consisted of making the initial radiographic record. Immediately afterward, the root canal opening was prepared using diamond burs and a multi-laminated type with a non-cutting tip, the endoZ model. Finally, instrumentation was performed using the apico-coronal technique and continued with lateral compaction of the canals. Once the procedure was completed, the samples were divided into two groups according to the type of condensation technique used to complete the obturation [Figure 1].

Lateral condensation filling technique

After verifying that the lateral condensation filling technique was adequate, all the cones at the entrance of the canal were cut and excessed with the help of a curette heated to the flame of a lighter. The gutta-percha cones were pressed into the canal entrance using a small condenser, a vertical condensation was performed, and an attempt was made to regularize the cervical surface of the obturation. Finally, using cotton in reduced portions soaked in alcohol and clinical forceps, all excess was removed.[9]

Modified lateral condensation technique

It was initiated by using a lighter and heat the tip of the attacker instrument (number 1 or code A) until it reached an orange color. Afterward, the instruments were placed toward the pulp chamber to cut the excess portion of the gutta-percha cones and remove the excesses. The tip of the shaping instrument (number 2 or code M) was then heated to an orange color. Following this, the instruments were placed toward the coronal-third of each of the root canals to achieve lateral condensation of the previously compacted gutta-percha material. Subsequently, the directing instrument (number 3 or code D) was placed at the entrance of the root canals, and vertical movements were generated to

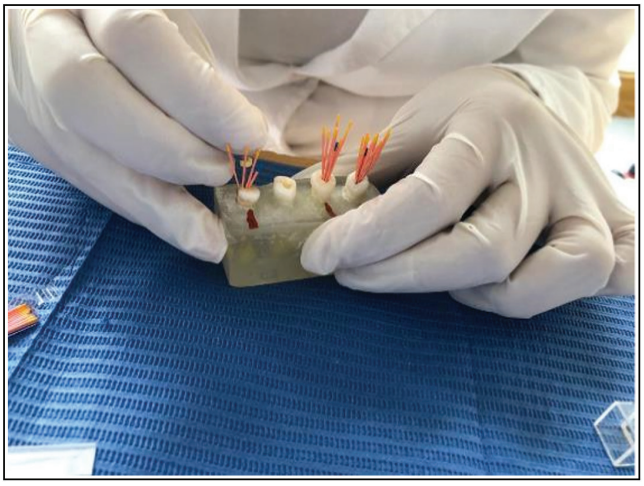

Figure 1: Preparation of endodontic root canals

direct the condensed gutta-percha toward the middle and apical portions of the root canal. Finally, the pulp chamber was cleaned using a cotton ball in reduced portions and soaked in alcohol.

Tomographic evaluation

Once the initial (post-biomechanical preparation) and final (post-obturation) tomographic recordings were made, these records were uploaded to the ITK-Snap program in which the tomographic volume was obtained. To perform this, the program asks the user to establish the area of interest and mention the density range, as the segmentation of the pulp chamber will be processed automatically [Figures 2 and 3]. After segmentation of the pulp chambers, the volume was obtained in cubic millimeters [Figure 4]. To obtain the void volume, the following formula was applied: Void volume = Initial volume – Final volume, and to obtain the percentage of voids in the seal, the following formula was applied:

$$\text{Void volume } \% = \frac{(\text{Initial volume} - \text{Final volume})}{\text{Initial volume}} \times 100.$$

Statistical analysis

The statistical analysis consisted of obtaining the arithmetic means and standard deviations. Additionally, the normality of the data was determined using the Shapiro–Wilk test. Finally, Student's *t*-test was used. All analyses were performed using the Stata 15 software (TX, USA).

Results

Regarding radiographic density, it was found that the lateral condensation obturation technique had a mean of 182.89 ± 9.81, whereas the modified lateral condensation technique presented the highest mean of 186.72 ± 6.97. When both groups were compared, no statistically significant differences were found ($P = 0.214$) [Table 1].

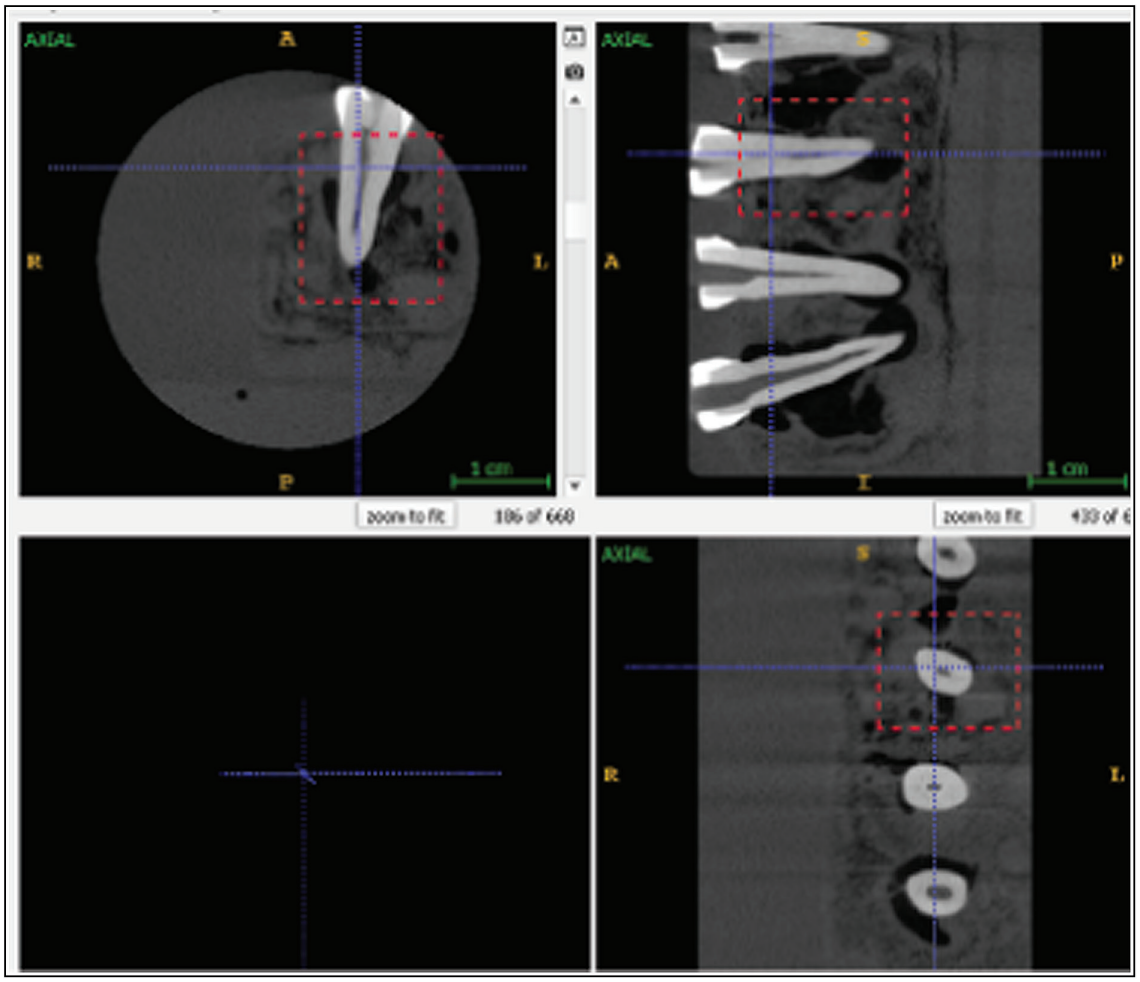

Figure 2: Delimitation of the region of interest in the three dimensions

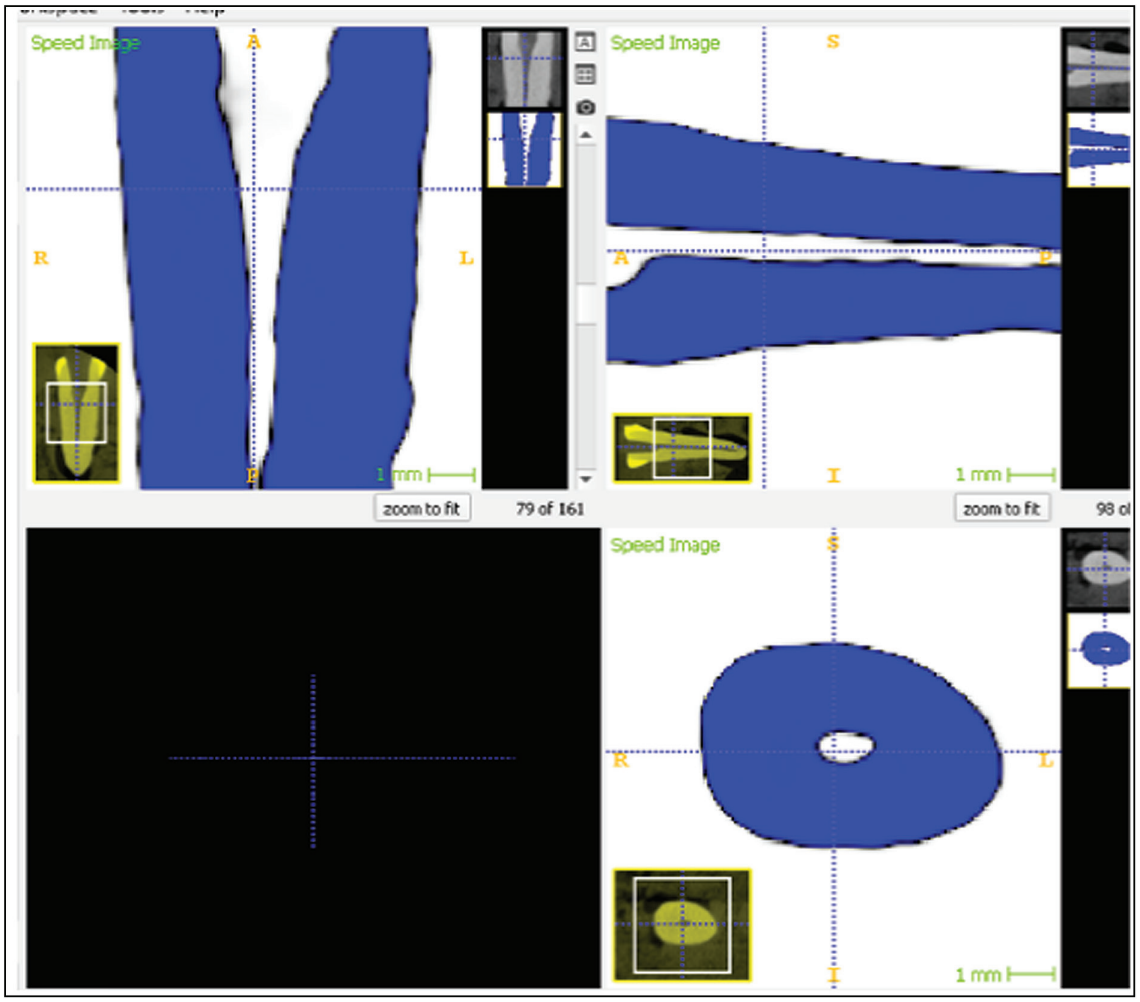

Figure 3: Establishment of density at the pulp chamber level

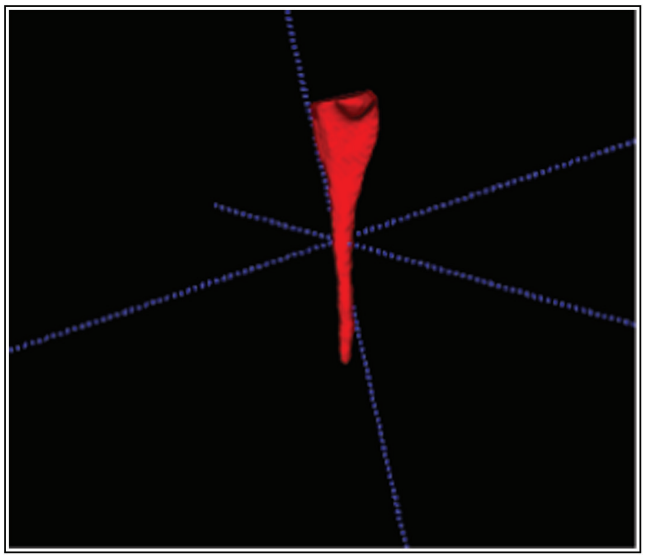

Figure 4: Evaluation of the three-dimensional volume of the dental pulp

In contrast, regarding the tomographic volume, it was evidenced that the lateral condensation technique had 3.75 ± 2.35, whereas the other modified lateral condensation technique had the lowest mean of 2.43 ± 1.18. However, no significant difference was observed ($P = 0.101$) [Table 1].

Discussion

The main findings of the present study were that radiographic radiodensity was 182.89 ± 9.81 and 186.72 ± 6.97 HU for teeth treated with the lateral condensation technique and the modified lateral condensation technique, respectively. In relation to volume, it was 3.75 ± 2.35 and 2.43 ± 1.18 mm^3 for teeth treated with the lateral condensation technique and the modified lateral condensation technique, respectively.

The quality of the endodontic treatment is a determining indicator to ensure good prognosis of the treated teeth, for example, the shape, level of filling, quality of condensation, adaptation of the master cone, among others, are considered. As it is not possible to directly observe the endodontic treatment, the quality assessment consisted of imaging whether the filling material had covered the entire structure of the

Table 1: Evaluation of the radiodensity and tomographic volume of the filling in root canals treated endodontically

Quality indicator	Obturation technique	Mean ± SD	CI	*P**	*P***
Radiodensity	Lateral condensation	182.89 ± 9.81	177.6–188.1	0.241	0.214
	Modified lateral condensation	186.72 ± 6.97	183.0–190.4	0.357	
Volume	Lateral condensation	3.75 ± 2.35	2.5–5.0	0.084	0.101
	Modified lateral condensation	2.43 ± 1.18	1.7–3.0	0.534	

Radiodensity was measured in Hounsfield units (HU) and tomographic volume was measured in mm^3. Statistical significance level (P <0.05). CI = confidence interval

*The Shapiro–Wilk test of normality

**Student's *t*-test

canal previously biomechanically worked. However, the prognosis of the tooth can also be affected by the quality of the final coronary restoration. Considering this, other studies, such as the systematic review and meta-analysis by Gillen *et al.*,[10] aimed to compare the impact of quality of root canal treatment versus quality of coronal restoration on treatment outcomes. This study concluded that both variables can influence the prognosis of the tooth similarly; therefore, the present investigation seeks to determine whether the modification of the lateral compaction technique can positively affect the quality of endodontic treatment through the most common standardized techniques to measure quality such as radiography and tomography.

The quality of the filling was evaluated according to the density of the filling, as measured by Barrieshi-Nusair *et al.*[11] A qualitative dichotomous scale was used to consider only poor and acceptable criteria. In contrast, the research by Carvalho-Junior *et al.*[12] performed a quantitative evaluation of radiographic density, as it performs an analysis on a section of interest and obtains values within the grayscale (0–255). Additionally, radiographs were recorded at a certain distance and exposure time; this consideration was also considered in the present investigation for investigation bias.[11,12]

To measure bulk density on a digital radiograph, Geiger *et al.*[13] used the ImageJ software (Wayne Rasband, NIH, USA), in which the procedure consisted of selecting the evaluation area, also known as the region of interest, and subsequently assigned a grayscale value to each pixel and obtained an average of all the values that make up the selection. The tomographic density allows us to determine the density of a given material. As long as the value is close to 255, the evaluated material will be highly radiopaque; consequently, it will have a higher density.[13]

The quality of the filling was evaluated according to the tomographic volume of voids, as measured by Iglecias *et al.*[14] This quantitative parameter was used to determine the difference between the tomographic volume of the post-biomechanical preparation canal and post-obturation canal, and the void volume was measured in mm^3. This measurement is optimal as it allows numerical evaluation of whether the canal was completely plugged; therefore, it will determine whether the root canal treatment is considered successful. According to the study by Nesković *et al.*,[15] the ideal way to demonstrate success would be by registering the absence of sensitivity in periodic check-ups for up to 2 years, post-operatively. This indicator would be considered, in case of replicating the present study in patients.

According to Yushkevich *et al.*, ITK-SNAP is a software tool that provides a graphical user interface for manual and user-guided semi-automatic segmentation of three-dimensional medical image datasets. This program was used by Schloss *et al.* to evaluate the volume changes in apical lesions after endodontic surgeries. In the present study, this program was used to perform the segmentation and volumetric measurement of the canal after biomechanical preparation and post filling to determine the magnitude of the void volume.[16,17]

The study by Celikten *et al.*,[18] which aimed to evaluate and compare the presence of voids in oval root canals filled with different root canal sealants (EndoSequence BC Sealer, Smartpaste Bio, ActiV GP) and to compare the root canals filled with AH Plus sealer using micro-tomography, used single-rooted teeth without the presence of curvatures, similar to the present study. These physical characteristics of the root canals chosen for the study will allow us to reduce the possibility of bias regarding the anatomical variants that multi-radicular pieces may present. However, further studies are necessary to assess the quality of filling using the modified lateral condensation technique in multi-radicular canals and curved root anatomy.

Ribeiro *et al.*[19] conducted a meta-analysis of studies that evaluated the quality of root canal treatment performed by university students. However, in the present study, it was decided to work with specialists, as the study aimed to evaluate the obturation techniques, however, not the quality of the operator's work.

Therefore, when choosing clinical operators specialized in endodontics, it is assumed that motor skills and experience guarantee that all samples were performed under optimal criteria, excluding the evaluation of the quality.

The quality of the filling evaluated by radiographic density obtained a mean of 182.89 ± 9.81 and 86.72 ± 6.97 HU for the groups of teeth treated with the lateral condensation and modified lateral condensation techniques, respectively. These results are above the radiographic density of 132.47 ± 6.71, associated with a 3 mm thickness of aluminum, which according to the study by Carvalho-Junior *et al.* is considered an ideal density for filling materials, in line with the American National Standard Institute/American Dental Association specification number 57. In the study by Colombo *et al.*, density was measured using a dichotomous radiographic density evaluation scale, considering that 82.84% of the teeth treated endodontically by graduate students had an optimal density, whereas Eskandarloo *et al.*, considering the same measurement parameter, obtained only 25.2% of optimal density in canals treated by undergraduate students.[12,20,21]

Regarding the quality of the obturation measured using the tomographic volume of voids, the present study obtained average values of 3.75 ± 2.35 and 2.43 ± 1.18 mm^3 for the groups of teeth filled using the techniques of lateral condensation and modified lateral condensation, respectively. The research by Huang *et al.* aimed to evaluate voids in different root canal sealants using micro-CT and nano-CT and to explore the feasibility of using nano-CT for the quantitative analysis of the quality of the sealant filling and had an average void volume of 0.243 mm^3. In contrast, the study by Iglecias *et al.*, which aimed to evaluate the presence of voids in the mesial root canals of the mandibular molars filled by using single-cone filling techniques and continuous condensation wave, obtained average values of 5.16 ± 1.85 and 5.42 ± 1.89 mm^3, respectively. Similar to the present study, it was determined that both evaluated techniques did not present significant differences between both techniques subjected to evaluation.[14,22]

The present study is of clinical importance as it proposes the use of the lateral condensation technique with modification to obtain better clinical results in the treatment of root canals. Furthermore, this study has theoretical importance given the existence of a few similar studies conducted in Peru that can contribute to the knowledge of the dentist on this subject, with the possibility of proposing improvements to the modification of the proposed technique for better results. It is methodologically important as it designs a dental positioning instrument to record standardized radiographs, controlling the distance and angulation of the radiographic equipment cone. Additionally, a radiographic measurement protocol was proposed to evaluate the quality of the filling based on the density obtained from digital radiographs.

Owing to the proposed modification of the lateral condensation method of root canal treatment, it should be initially evaluated in an environment that simulates the conditions present in the oral cavity; therefore, the study design will be experimental *in vitro*. The first limitation was that the study could only be conducted with the use of extracted teeth. The teeth selected for this study lacked pulp pathology to unify criteria; therefore, the teeth extracted without the cause of pulp pathology were those that presented with loss of periodontal support or severe dentoalveolar discrepancies in orthodontics. Consequently, the second limitation of the study was that the sample comprised premolars with a single root canal.

The density of the filling material can ideally be measured by three-dimensional segmentation of the filling material from a micro-CT. Consequently, the third limitation of the study is that tomographic recording of this type would imply excessively raising the research budget. In view of this, cone beam tomographic records (CBCT) will be used, and the standardization of the inclination and distance of the digital radiography will be carried out and a program will be used that will allow the segmented two-dimensional measurement of the density of the filling material to obtain two parameters of the quality of the shutter.

For future studies, it is suggested to evaluate the quality of obturation in curved canals and to carry out studies in patients and to carry out a clinical and radiographic follow-up of the canal treatment. Finally, to the dental community, it is suggested to make periodic evaluations of radiographic density or of the tomographic volume of voids to measure the quality of endodontic treatment that they achieve with the techniques that are usually applied for the treatment of root canals.

Conclusion

There was no statistically significant difference between the radiographic density and tomographic volumes of the root canals filled using the lateral condensation technique and the modified lateral condensation technique.

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None to declare.

Conflicts of interest

None to declare.

Authors' contributions

Study conception (A. M.-D., C. L.-F., C. G.-G.), data collection (A. M.-D., C. L.-F., C. G.-G.), data acquisition and analysis (F. M.-T., D. A.-T., R. M.), data interpretation (F. M.-T., A. M.-D., R. M., D. A.-T.), manuscript writing (A. M.-D., F. M.-T., D. A.-T., R. M.).

Ethical policy and institutional review board statement

This study used inert dental materials for which it was exempted from review by the Ethics Committee, as it was clearly an experimental *in-vitro* study.

Patient consent statement

Not applicable.

Data availability statement

The data that support the study results are available from the author (Dr. Arnaldo Munive-Degregori, e-mail: amunived@unmsm.edu.pe) on request.

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