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Adaptation of a Single-Cone in Prepared Teeth with Two Reciprocating Systems

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ABSTRACT

Introduction: This *ex vivo* study aimed to compare the adaptation of single gutta-percha cone in teeth prepared with the Wave One Gold and Reciproc Blue reciprocating systems through cone-beam computed tomography. **Materials and Methods:** A total of 40 recently extracted mono radicular premolars were randomly assigned into two groups (n=20) corresponding to Reciproc Blue and Wave One Gold reciprocating systems and adapted to a single cone system. Each group was evaluated by cone-beam computed tomography at 1 mm, 2 mm and 4 mm from the apical foramen. We evaluated the number of walls adapted by the cone, quality of filling and the number of spaces between the filling and the walls of the root canal. The Mann-Whitney U and T-tests were employed to associate and compare both groups (P<0.05). **Results**: At 1 mm in the lingual wall the Wave One Gold system did not adapt by 45% compared to 15% with Reciproc Blue (P<0.05). Likewise, the single-cone filling technique of the Reciproc Blue system showed better sealing quality obtaining an ideal category (75%) compared to Wave One Gold (40%) (P<0.05). The amount of space (mm) found between the cone and the filling walls was greater with Wave One Gold. However, these values were not statistically significant. **Conclusions**: Based on this *ex vivo* study the better adaptation of root canals and ideal filling condition was more frequent with Reciproc Blue than Wave One Gold system, mainly at 1 mm from the radicular apex.

Keywords: Cone Beam Computed Tomography; Root Canal Obturation; Single Cone Obturation

Introduction

At the moment of preparing the root canal system, the apical configuration is a priority at the moment of choosing the instrumentation system since an optimal preparation precedes a correct filling which guarantees a hermetic seal which means the success of the endodontic therapy [1-3]. Several instrumentation systems are proposed in order to achieve a correct apical preparation, which with their design and mechanization of the movement improve the three-dimensional spatial configuration of the lumen and walls of the root canal obtaining correct adaptation to the morphology of the root canal [4, 5].

Specifically, each instrumentation technique has a single cone filling system which has an identical configuration to the instrument used in the root shaping that includes diameter at the tip and conicity in its extension which would ensure a complete and accurate adaptation of the cone along the root canal [6-8].

Different methods have been defined to evaluate the adaptation and quality of the filling in which the tactile and visual through radiographs are those that the clinician tests to evaluate the adaptation after the cone reaches the established and worked length, but currently there are no reports of a single cone filling system with complete and optimal adaptation in the root canal system [9-12].

Implementing the use of cone-beam computed tomography (CBCT) in endodontics is nowadays a strength in clinical practice since it allows an accurate analysis and evaluation of the root canal configuration and therefore an appreciation of the quality of the filling procedures by allowing a three-dimensional visualization [13-15].

When studying the adaptation of single cones belonging to rotary systems, it was reported that despite obtaining a tactile and visual adaptation through satisfactory radiographs from the operator, by means of visualization and tomographic evaluation an adaptation of only 76.66% and of 51.11% was evidenced in the vestibular and lingual walls respectively, compared to a total adaptation of 100% and 98.9% in the mesial and distal respectively [16]. The presence of this alteration is related to the impossibility of the rotary instrumentation systems to conform the root canal system respecting the spatial configuration of the same, which with concentric movements only achieve a circular preparation of an oval disposition canal and therefore wear with greater aggressiveness the mesial and distal walls that make up the smaller diameter of the canal [17, 18].

Instrumentation systems with reciprocating movement are those that currently allow the preparation of the canal respecting its anatomy, allowing to prepare all the walls following its original oval arrangement [19, 20]. Nowadays, it is recommended that cases prepared with a reciprocating rotary instrumentation system be sealed with the single cone filling technique, developed in particular by each of them in order to guarantee the manufacturing of the master cones, which would coincide in precise diameter with the instrument used in the preparation. However, the concordance in the general arrangement of the single cone from the reciprocating systems has been studied recently, with the reciprocating instrument, showing that along the distribution of the cone, there are significant differences in the diameter of the Reciproc cone (VDW, Munich, Germany), being smaller in comparison with the Reciproc R25 (VDW, Munich, Germany) [21]. On the other hand, when evaluating the Wave One cones (Dentsply Maillefer, Ballaigues, Switzerland), they showed variability in the conicity, being lower in D1 (tip) compared to the file; but in D3, it showed an increase in diameter, which was greater in comparison with the instrument, that may condition the adaptation and apical seal [22].

Currently, very few reports of imaging evaluation through radiographs and tomographies of single cone filling adaptation of reciprocating systems exist. For this reason, the purpose of this study is to compare the adaptation of the single cone in teeth prepared with Wave One Gold (Dentsply Maillefer, Ballaigues, Switzerland) *versus* Reciproc Blue (VDW, Munich, Germany) reciprocating systems using digital radiography and CBCT.

Materials and Methods

This *ex vivo* study was approved by the ethics committee of the Universidad Científica del Sur with protocol number 291-2018-POS8. The study group included 40 mono radicular premolar teeth extracted by orthodontic indication, with a curvature degree of up to 20º (Sheneider *et al.* 1971) [23], which were included in the research under the signed consent of the donor patients. Two groups of 20 premolars (n=20) each one were conformed, obtained by a unilateral test with a confidence level of 95% and a power of 80% through Fisterra Clinical Epidemiology Research software, University of Coruña (http://www.fisterra.com) , and were randomly assigned to be prepared with the Wave One Gold or Reciproc Blue systems and sealed with the single cone systems and later evaluated using a CBCT scan.

All the teeth were initially submerged in 2.5 % sodium hypochlorite for 2 h to degrade the remains of the periodontal ligament and then the remnants were removed mechanically [24]. Subsequently, they were washed with plenty of water and immersed in 0.2% sodium chloride solution and thymol [15].

Teeth with two or more canals, previous endodontic treatment, incomplete roots, root resorption, fractures, or open apex were excluded from the study. These inclusion and exclusion criteria were corroborated with CBCT.

Endodontic preparation

The endodontic access was made with round #4 diamond burs, obtaining conformation and compensatory wear according to the anatomical disposition. Once the root canal is located it is necessary to determine the length of the canal with a #10 K-Flexofile (Dentsply Sirona Endodontics, Ballaigues, Switzerland), passing the apical foramen and, once it is visible, subtracting 1 millimeter from that length,; thus, standardizing the length 1 mm from the apical foramen. The conductometry was performed with an instrument that adjusted to that determined length and verified radiographically. All of the teeth were manually instrumented up to a number #20 K-Flexofile (Dentsply Sirona Endodontics, Ballaigues, Switzerland) (glide path), irrigating with 2.5% sodium hypochlorite. Subsequently, the preparation was carried out with the reciprocating systems distributed in group 1 with Reciproc Blue (R25, 25/0.08) (VDW, Munich, Germany) and group 2 with Wave One Gold (Primary, 25/0.07) (Dentsply Sirona, Ballaigues, Switzerland) instruments. Both systems were activated with a Silver Reciproc VDW engine (VDW, Munich, Germany) with contra angle, 6:1 of torque and pre-set revolutions for each. The instrumentation consisted in movements of 3 pecks in each root

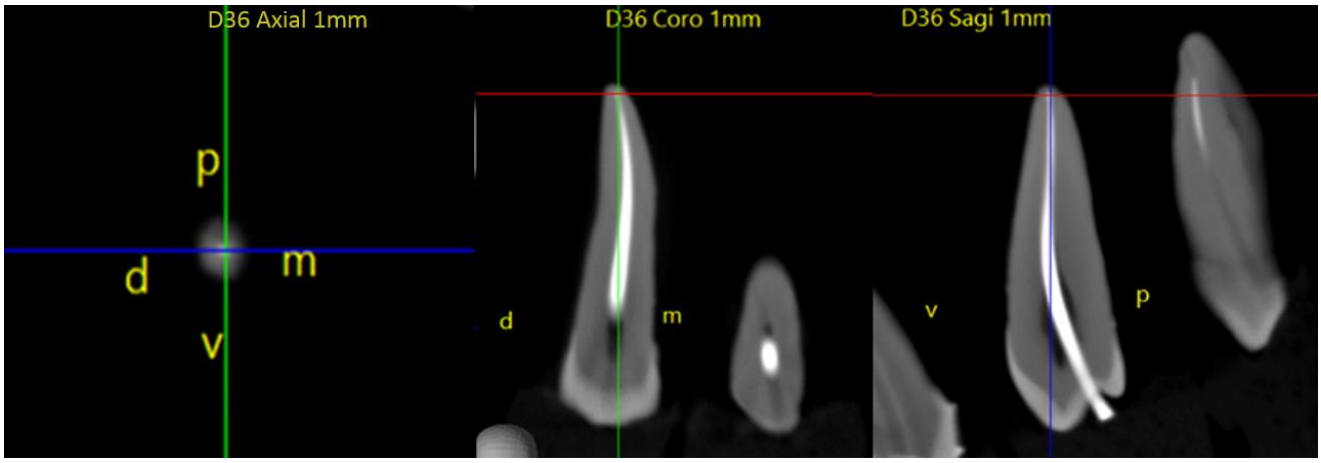

Figure 1. Evaluation through CBCT; initial orientation of the sample according to the major axis of the teeth to be evaluated

third, irrigating as the instrument advances in the canal. The preparation culminated when reaching the apical limit (working length), where the adaptation of the single cone was made, similar to the R25 and Primary preparation system. All roots were prepared by the same expert endodontist operator (JFA).

Adaptation evaluation

Tactile adaptation evaluation was carried out in each group, which consisted of the sensation of opposition of the cone to be removed from the canal and its radiographic and tomographic evaluation was carried out.

Radiographic adaptation evaluation

Each simple had a radiograph taken followed by its digitalization using the Scan DIGORA™ Optime DXR-60 phosphor plate reader system (Soredex Orion Corporation, Helsinki, Finland), with a pixel size of 60 µm and 17 µ/mm resolution. The radiographic images were taken from the vestibular face of the teeth and recorded with the software of the system to allow the manipulation of contrast, inversion (radiopacity/radiolucency) and zoom in order to improve visualization. Therefore, it was possible to evaluate if the cone corresponded to the working length and if its contact with the mesial and distal walls of the root canal was adequate.

Tomographic adaptation evaluation

The images were obtained using an Accuitomo 170 (J Morita Corp, Kyoto, Japan) CBCT scan, with a FOV of 40×40 mm and an 80 µm Voxel size, the equipment was programmed in high-definition mode, placing the teeth in a standardized holder for the acquisition of images, a 360º full scan was performed, using an exposure factor of 80 kv and 2.0 mA during 30 sec, and its analysis was carried out in the i-Dixel 2.0 software (J. Morita Corp, Kyoto, Japan) .

The images were three-dimensionally analyzed by the head examiner, an expert endodontist (JFA), for the following criteria: level of adaptation in apical thirds (at 1, 2 and 4 mm from the apex), number of walls to which the cone was adapted between 0 and 4 and the walls in which the cone is adapted to (buccal, lingual, mesial and distal) (Figure 1).

Hypodense spaces between the gutta-percha and the inner root canal walls indicated a lack of adaptation of the cone. In addition, a measurement in millimeters of the surface without adapting was carried out to determine the amount of space not reached by the gutta-percha cone in the different thirds (Figure 2). The measurements were made with the zoom tool with 300× magnification. The criteria for the classification of the adaptation of the gutta-percha cones to the walls of the canal are ideal, satisfactory, minimally acceptable, or unsatisfactory, determined by the number of walls or surfaces to which the single cone adapts in valuation of 4, 3, 2, 1 and 0, respectively.

The head examiner was trained with an experienced oral and maxillofacial radiologist (DAE), in the correct management of the software tools and the correct measurement of the variables and. Two measurements were made in 30% of the simple with one-month interval, these values were evaluated through the interclass correlation coefficient to determine the intra-examiner concordance, with an estimated value greater than 0.8. Likewise, Dahlberg's error for quantitative variables was obtained and the value was less to 1 mm. Finally, to evaluate the reproducibility in the qualitative variables the Kappa index was employed, and the value was higher than 0.8 in all evaluations.

Statistical analyses

Statistical analysis of the data was carried out using the Statistical

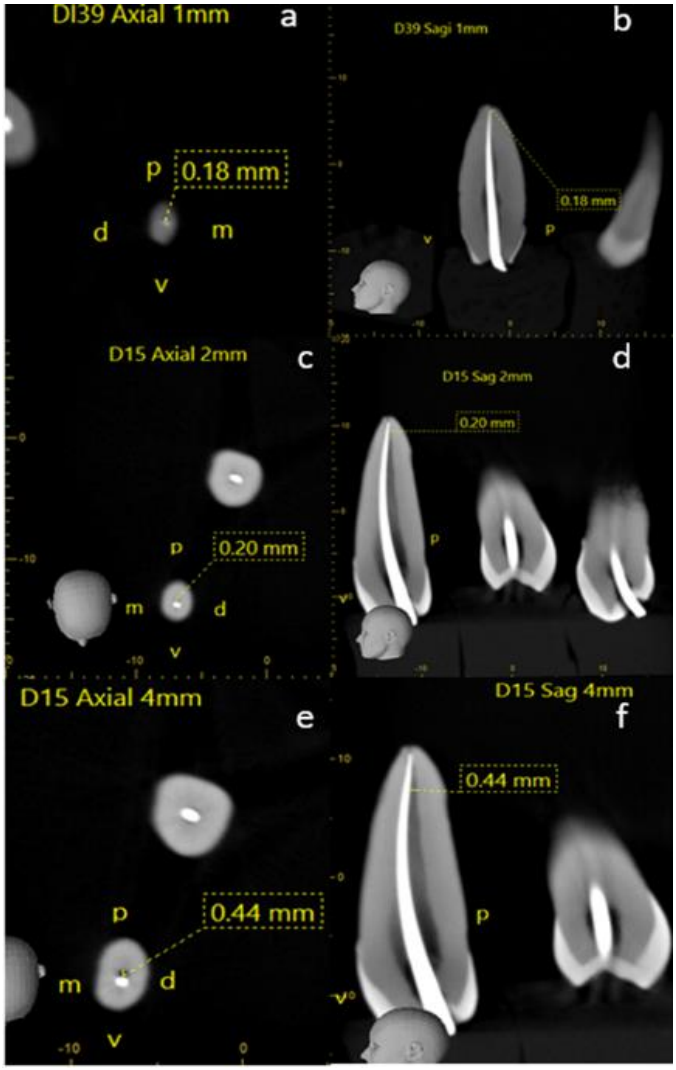

Figure 2. Evaluation and quantification of space according to the sections, a and b evaluation at 1 mm; c and d evaluation at 2 mm; e and f evaluation at 4 mm, in axial and sagittal sections due to the presence of space in relation to the lingual wall

Package for the Social Sciences (SPSS) for Windows (SPSS version 22.0, IBM, Armonk, NY, USA). The statistical analysis was carried out by describing the variables number, type of surfaces and amount of space sealed by the adapted cone. For the qualitative variables, they were associated using the Chi-Square test to the reciprocating system used in both measuring instruments and the relationship between the number of adapted walls and the preparation and sealing technique based on the evaluated cut was used. In addition, for the amount of sealed space the normality of the data was evaluated with the Shapiro Wilk test, and then averages were compared with the Mann-Whitney U and Student's T test. The significance level was $P<0.05$.

Results

At 1 mm from the radicular apex, the number of walls of the root canal adapted by the single cone of the filling systems is significantly affected, with a 75% total adaptation of the 4 surfaces with the Reciproc Blue system compared to the Wave One Gold system that evidenced 40% ($P<0.05$) (Table 1). At 2 mm and 4mm cuts from the radicular apex, although the Reciproc Blue system continues to perform better than the Wave One Gold system, on all the evaluated surfaces, no association with statistical significance was found ($P>0.05$).

Among the 4 surfaces of the root canal, the lingual face, through the different sections evaluated (1, 2, and 4 mm) was the one that showed less adaptation when comparing the two filling techniques, observing that with Wave One Gold it did not adapt in 45%, 15% and 50% respectively, while Reciproc Blue showed 15%, 5% and 20% ($P<0.05$) (Table 2).

The single cone filling technique of the Reciproc Blue system showed better sealing quality, especially when evaluating 1 mm cuts obtaining an ideal category in 75% of the cases compared to the Wave One Gold system that showed 40% ($P<0.05$) (Table 3).

The average amount of space found between the cone and the filling walls was greater with Wave One Gold in the different cuts, mainly in relation to the lingual surface, although this value is not statistically significant ($P>0.05$) (Table 4).

Discussion

The present study evaluated the quality of adaptation of the single cone technique in the Reciproc Blue and Wave One Gold systems. The hermetic sealing of the root canal, especially in the apical region (until 4 mm from the radicular apex) is the critical point in the filling process which guarantees endodontic treatment success. This hermetism is achieved when the filling material fits correctly into the canal space, making full contact with the walls of the root canal [25]. According to the results of the present study, this perfect adaptation of the filling material can be affected mainly in the first apical millimeter when filling with the Wave One Gold single cone system compared to Reciproc blue.

Within the principles of preparation and endodontic filling, the diameter and caliber of the gutta-percha cones play an important role in the correct adaptation in the canal and its choice by the operator depends on the technique and preparation systems since the spatial conformation will be

defined by the last instrument used mainly in the apical region (last millimeters) and the cone must match in diameter to that configuration [26].

Mechanized systems have among their advantages the use of a single cone as a filling technique that matches the configuration, conicity and diameter of the instruments used in the shaping of the root canal. Therefore, it is proposed that when performing the instrumentation with these systems the filling will show a correct adaptation of the cone along the entire length of the canal [27].

Several studies have reported that when filling with single cones, a correct total adaptation of the material in the walls of the canal has been achieved, achieving effective fillings in the apical portion [28, 29]. However, in this study it was observed that although a correct tactile and radiographic adaptation of the single cone was obtained within all the prepared roots; by tomographic evaluation, a complete and correct adaptation of the cone in the apical third was not observed, not adapting in all the surfaces of the root canal. This may be supported by the impossibility of the reciprocating preparation systems to perform totally eccentric movements, which does not allow to prepare completely the original anatomical conformation of the root canal and which does not guarantee optimal sealing by the single cone system [30-32].

Table 1. Number of root walls adapted by the filling system of the two techniques

Cut to evaluate	Filling technique (N)	0	1	2	3	4	*P*
		N (%)	N (%)	N (%)	N (%)	N (%)	
1 mm	**Reciproc Blue (20)**	0 (0)	1 (5)	2 (10)	2 (10)	15 (75)	0.041*
	Wave One Gold (20)	0 (0)	3 (15)	0 (0)	9 (45)	8 (40)	
2 mm	**Reciproc Blue (20)**	0 (0)	0 (0)	1 (5)	3 (15)	16 (80)	0.072
	Wave One Gold (20)	0 (0)	0 (0)	1 (5)	10 (50)	9 (45)	
4 mm	**Reciproc Blue (20)**	0 (0)	0 (0)	1 (5)	3 (15)	16 (80)	0.114
	Wave One Gold (20)	0 (0)	0 (0)	2 (10)	8 (40)	10 (50)	

** Significance Statistics by Mann-Whitney u test*

Table 2. Condition of adaptation of the filling system in the different root surfaces according to the evaluated cut

Surfaces	Cut to evaluate (N)	Reciproc Blue		Wave One Gold		*P*
		Adapted	Not Adapted	Adapted	Not Adapted	
		N (%)	N (%)	N (%)	N (%)	
Mesial	**1 mm (20)**	20 (100)	0 (0)	19 (95)	1 (5)	0.311
	2 mm (20)	20 (100)	0 (0)	20 (100)	0 (0)	1.000
	4 mm (20)	20 (100)	0 (0)	20 (100)	0 (0)	1.000
Distal	**1 mm (17)**	17 (85)	3 (15)	17 (85)	3 (15)	1.000
	2 mm (19)	19 (95)	1 (5)	20 (100)	0 (0)	0.311
	4 mm (20)	20 (100)	0 (0)	20 (100)	0 (0)	1.000
Vestibular	**1 mm (17)**	17 (85)	3 (15)	15 (75)	5 (25)	0.429
	2 mm (19)	19 (95)	1 (5)	17 (85)	3 (15)	0.292
	4 mm (19)	19 (95)	1 (5)	18 (90)	2 (10)	0.548
Lingual	**1 mm (17)**	17 (85)	3 (15)	11 (55)	9 (45)	0.038*
	2 mm (19)	19 (95)	1 (5)	17 (85)	3 (15)	0.038*
	4 mm (16)	16 (80)	4 (20)	10 (50)	10 (50)	0.047*

** Significance Statistics by Chi square test*

Table 3. Comparison of the quality of filling of the two techniques compared to the level of the evaluated cuts

Cut to evaluate	Filling technique (N)	Unsatisfactory	Minimally acceptable	Satisfactory	Ideal	*P*
		N (%)	N (%)	N (%)	N (%)	
1 mm	**Reciproc Blue (20)**	1 (5)	2 (10)	2 (10)	15 (75)	0.045*
	Wave One Gold (20)	3 (15)	0 (0)	9 (45)	8 (40)	
2 mm	**Reciproc Blue (20)**	0 (0)	1 (5)	3 (15)	16 (80)	0.070
	Wave One Gold (20)	0 (0)	1 (5)	10 (50)	9 (45)	
4 mm	**Reciproc Blue (20)**	0 (0)	1 (5)	3 (15)	16 (80)	0.114
	Wave One Gold (20)	0 (0)	2 (10)	8 (40)	10 (50)	

** Significance Statistics by Mann-Whitney u test*

The oval configuration of the root canal system makes it impossible for a preparation and filling system of centric properties to prepare and adapt the entire surface of the root canal. Studies have shown that there are no statistical differences when preparing root canals with rotary and reciprocating movement systems according to the conformation and maintenance of the original configuration of the root canal that affects the total adaptation of the filling material [33, 34]. However, in our study it was shown that when preparing with reciprocating systems, the wall on which the cone showed less adaptation was the lingual one, contrary to the previous studies that show the mesial and distal walls with the highest percentage, this condition was obtained, despite the positive tactile sensation and the correct radiographic image achieved in this study.

When analyzing the quality of the fillings from the two compared systems in this study, Reciproc Blue showed better sealing quality compared to Wave One Gold, mainly when evaluating the 1mm cut of the apical section. This contrasts with studies that report that when analyzing the cone and file conformation of reciprocating systems, the Reciproc cone shows significantly a reduction in diameter and conicity compared to the file, which would prevent a correct adjustment of the root canal system [35], differing from recent studies that conclude that the diameter of the coronal portion is greater respecting the file, although it maintains equality in D1 (tip) with the instrument, compared to Wave One, which also has a D1 corresponding to the file but in D3 it increases its diameter and conicity [36, 37], which is why it would explain the low percentage of ideal filling quality obtained in this study, since it would avoid the total adjustment of the cone in the entire length of the instrumented canal.

An ideal filling supposes a perfect adaptation between the material and the walls of the canal, which translates in the absence of spaces. There are reports in which they compared the quality of the filling analyzing the presence of spaces and the percentage of the canal sealed by the sealing cement, which, in spite of yielding higher values for Wave One, were not statistically significant [38]. Similar results are presented by this study in which, despite the fact that the apical third to 1mm, and the lingual wall in roots filled with Wave One Gold® cones presented higher average, no significant difference was found between the two systems.

Table 4. Evaluation of the amount (mm) of space present between the walls of the root canal and the filling material of the two techniques

Cut to evaluate	Surfaces	Filling technique	Mean	Mean difference	95% CI		*P*
					LL	UL	
1 mm	Vestibular	Reciproc Blue	0.02 (0.69)	-0.038	-0.10	0.02	0.214
		Wave One Gold	0.06 (1.11)				
	Lingual	Reciproc Blue	0.03 (0.84)	-0.063	-0.13	0.00	0.071
		Wave One Gold	0.09 (1.12)				
	Mesial	Reciproc Blue	0.00 (0.00)	-0.009	-0.02	0.00	0.324
		Wave One Gold	0.01 (0.04)				
	Distal	Reciproc Blue	0.02 (0.65)	-0.004	-0.03	0.04	0.814
		Wave One Gold	0.02 (0.05)				
2 mm	Vestibular	Reciproc Blue	0.01 (0.05)	-0.033	-0.08	0.01	0.214
		Wave One Gold	0.04 (0.10)				
	Lingual	Reciproc Blue	0.04 (0.13)	-0.078	-0.18	0.02	0.127
		Wave One Gold	0.12 (0.17)				
	Mesial	Reciproc Blue	0.00 (0.00)	0.00	---	---	---
		Wave One Gold	0.00 (0.00)				
	Distal	Reciproc Blue	0.04 (0.17)	-0.04	-0.04	0.02	0.324
		Wave One Gold	0.08 (0.00)				
4 mm	Vestibular	Reciproc Blue	0.01 (0.06)	-0.071	-0.17	0.37	0.194
		Wave One Gold	0.08 (0.23)				
	Lingual	Reciproc Blue	0.10 (0.22)	-0.112	-0.28	0.06	0.204
		Wave One Gold	0.21 (0.31)				
	Mesial	Reciproc Blue	0.00 (0.00)	0.00	---	---	---
		Wave One Gold	0.00 (0.00)				
	Distal	Reciproc Blue	0.00 (0.00)	0.00	---	---	---
		Wave One Gold	0.00 (0.00)				

Independent T-Student test

The guarantee of a hermetic sealing of the seal is the total adaptation of the material to the walls of the canal, without the presence of space since these will be filled with the sealing cement, in spite of the various innovations, one has not been found that is completely stable that guarantees sealing and permanent adhesiveness without losing its structure, which would allow the presence of cracks and therefore filtration and endodontic failure [39].

Wu *et al.* concluded that whenever the filling is performed with single cone systems, it is necessary to use more sealing cement, evidencing difficulty in the adaptation of this filling system in the root canal [40]. However, De Deus *et al.* [41] concluded that when sealing with thermoplasticized filling techniques, the Thermafil (Dentsply, Tulsa Dental Products, Tulsa, OK, USA) system, was the one with the best behavior, diminishing the presence of spaces between the walls and the sealing material, which allows the sealing and adhesion to be carried out with a significantly smaller amount of sealing cement, even when compared to thermoplastic continuous wave systems, which reduces the risk that due to chemical structural failure and loss of physical properties of the cement, cracks appear and spaces that end in filtration and endodontic failure [41]. It is for this reason that the use of filling systems that modify the gutta-percha mainly with a temperature increase are gaining ground every day in endodontic practice because they allow a more correct adaptability of the material to the walls of the canal by decreasing the appearance of spaces, which guarantees a hermetic seal. Finally, future studies can compare these filling systems with thermoplastic techniques and evaluated with more precise technologies such as micro tomography to compare the results.

Conclusions

The better adaptation of root canals and ideal filling condition was more frequent in the Reciproc Blue than the Wave One Gold system, mainly at 1mm from the radicular apex and in the lingual wall. However, although these spaces were larger in the Wave One Gold technique group, these amounts do not show statistical difference.

Therefore, we recommend the implementation of obturation techniques such as thermoplasticized gutta-percha and flowable gutta-percha technique which have a better adaptation in the root canal system, reducing the possibility of the presence of unobstructed spaces and improving the endodontic success rate.

Conflict of Interest: 'None declared'.

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