

Influence of three Endodontic Filling Techniques in Filling Simulated Side Canals

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Abstract— Root canal filling is one of the stages of endodontic treatment that deserves special attention, being responsible for the final sealing, avoiding recontamination and reinfection in that space. The objective of this research was to evaluate in vitro the influence of three endodontic filling techniques in the filling of simulated lateral canals, these being the Lateral Condensation Technique, Continuous Wave Technique and Hybrid Tagger Technique. Thirty lower premolar teeth were used, which were divided into three groups ($n = 10$) for comparisons of filling techniques. The chemical-mechanical preparation was carried out with Protaper Universal rotary files, then lateral canals at the apical, medium and cervical level were made with an LN drill. The teeth were filled and evaluated with digital radiography considering the amount of simulated canals that were filled by the filling material. The results were subjected to statistical analysis using the non-parametric Chi-square test, in which a statistical difference was considered when $p < 0.05$. The lateral condensation technique showed the lowest results with a statistically significant difference ($p < 0.05$), when compared to the Tagger hybrid and continuous wave, however there was no statistical difference between the Tagger hybrid technique and continuous wave ($p > 0.05$). It was concluded that none of the three techniques was able to fill all the simulated lateral channels. The continuous wave technique presented the largest amount of pre-filled lateral canals, followed by the Tagger hybrid technique and lateral condensation.

Keywords— Lateral canals. Endodontic cement. Obscuration techniques.

I. INTRODUCTION

The various techniques, studies and discoveries that constantly gain space in the scientific scope with regard to —health, focus on ensuring this for the individual in a safe and effective way. Scientific research has a significant role, as it contributes to a safe clinical practice for both the patient and the professional. It is in this perspective that advances in the dental field occur as new research is published. Endodontics in turn brings with it a substantial part of these studies, which result in the development of various techniques and materials.

As described by Alonso et al. (2005), in order to be successful in endodontic treatment, it is significant that all its phases are performed with mastery, and within these phases is the root canal filling. The filling, despite being one of the last stages of endodontic treatment, deserves special attention since it is responsible for the final sealing of the root canal, which will act as a barrier against the occurrence of recontamination and reinfection in that space.

The filling of the root canal, after adequate cleaning through the instrumentation, occurs with the use of gutta-percha cones combined with the obturator cement. Gutta-percha fills the central space that was modeled. The filling cement fills the irregularities of the root canal, promotes a better adaptation of the gutta-percha cone to

the dentin walls and is responsible for filling the lateral canals (ALONSO et al., 2005). For Camões et al. (2007), the three-dimensional hermetic filling of the root canal system is essential, since it prevents the microleakage of the periapical exudate into the space of the canal, preventing reinfection and creating a biologically favorable environment for tissue healing to occur.

As mentioned by Rebouças et al (2013), the lateral compression technique has been the most used root canal filling technique in recent years, being a technique well dominated in practice by clinicians and endodontists as well as being used as a standard technique for comparing the filling of the root canals.

Lopes and Siqueira (2015) describes that the lateral compaction technique seems to have been initially proposed by Callahan in 1914, being a technique that uses accessory cones placed laterally to a main cone and that through the use of spacers the spaces are created for the placement of accessory cones.

In view of the complicated morphology of the root canal system, such as anatomical irregularities, curvatures, atresias and various branches that hinder the three-dimensional filling of this entire system, the plastification of gutta-percha has been recommended in different techniques. Thus contributing to the complete filling of the pulp space, seeking a sealing resistant to the

penetration of fluids and microorganisms in the root canal system (LOPES and SIQUEIRA, 2015).

The hybrid Tagger technique consists of a combination of cold lateral compaction, followed by gutta-percha thermoplasticization. After obturation of the apical segment by lateral compaction, the obturation of the middle and cervical segments is completed through the application of a compactor that is activated in the root canal, in a clockwise direction, generating heat by friction, plasticizing the gutta-percha and promoting the compaction. lateral and apical view of the filling material (LOPES and SIQUEIRA, 2015).

The continuous wave technique promotes a good filling of the root canal, it uses the thermoplasticized gutta-percha that fits in the dentin irregularities. For this, a heat generating device is used which, through a cable, takes this heat to the side condenser called pluggers. The same plasticizes and condenses the gutta-percha, filling the apical third and then the middle and cervical thirds are filled with the plasticized gutta-percha inside the root canal (LEONARDO and LEONARDO, 2017).

Obturation techniques play a substantial role in endodontics. Thus, knowing and evaluating the efficacy of filling techniques that promote adequate pre-filling of lateral canals is significant for a good prognosis for endodontic treatment.

Therefore, this research aims to evaluate in vitro the influence of three endodontic filling techniques in the filling of simulated lateral canals.

II. METHODOLOGY

For the research, 30 lower premolar teeth were used, which were donated by patients and professional dental surgeons. After collection, the teeth were stored in a 1% thymol solution for 20 days before the start of the trial. All dental elements were radiographed (Schick - DMM Health - Brazil) and one week before the test, they underwent scraping with periodontics curettes (Millennium-Golgran, São Paulo -SP) to remove the remaining periodontal ligament (Figure 2) and prophylaxis was performed using a Robson brush (Microdont, São Paulo - SP) pumice stone and water.

After cleaning, the crown section of the teeth was performed, with a diamond tip (Dentsply / Maillefer, Ballaigues - Switzerland) in a high-speed motor (Kavo - Brazil) cooled with air / water spray. The length of the roots was standardized at 15mm with the aid of a digital caliper (MTX, Curitiba - PR).

For instrumentation, visual dentometry was determined. A file type K # 10 (Dentsply / Maillefer, Ballaigues - Switzerland) was introduced in each canal, until its visualization in the apical foramen.

The instrumentation was performed using ProTaper Universal rotary files (Den-tsply / Maillefer, Ballaigues - Switzerland) coupled to the X-SMART endodontic engine (Dentsply / Maillefer - Switzerland). The files used were SX in the cervical and middle third and S1, S2, (Figure 7) F1, F2, F3 at the determined working length.

After the chemical-mechanical preparation, lateral canals were made with an LN drill (Dentsply / Maillefer, Ballaigues - Switzerland) on all teeth (figure 9), 6 lateral canals, 3 on the mesial and 3 on the distal, 1 in each third (cervical, middle and apical).

During the cleaning and shaping of the root canals, they were irrigated at each instrument change with NaOCl 2.5% (Formula Mais, Palmas - TO) in a total of 20 ml of solution per experimental unit, 1 mm below the working length. After instrumentation, passive ultrasonic irrigation was performed (figure 10). As described by (Van der Sluis, 2010), using the 20.1 irrisonic insert (Helse - Brazil), inserting it 2mm of the working length at a frequency of 30,000 Hz. 3 cycles of 20 seconds were performed with NaOCl 2, 5% (5 ml), 3 20-second cycles with 17% liquid EDTA (5 ml) (Formula and Action - São Paulo - SP), proceeding with another 3 20-second cycles with 2.5% NaOCl (5 ml). Then, the canals were dried with an aspiration cannula and with absorbent paper tips.

After chemical-mechanical preparation, the teeth were divided into three groups at random to perform filling techniques. In group 1 the lateral compression technique was performed, in group 2 the hybrid Tagger technique and in group 3 the continuous wave technique. In the three experimental groups, Sealer 26 cement (Dentsply / Maillefer, Munich - Germany) was used.

Sealer 26 cement was spatulated on a glass plate, adding the powder gradually to the resin, until a smooth and homogeneous mixture was obtained which, when lifted using the spatula, breaks at a height of 1.5 to 2.5 cm above the glass plate. It's ideal proportion is approximately two to two to three parts of powder to one of resin per volume (LOPES and SIQUEIRA 2015). The filling cement was mixed in a glass plate with a flexible metallic spatula (Golgran, Millennium - Brazil).

GROUP I: Lateral condensation technique

The completion of the filling technique in this group was as described by Lopes and Siqueira (2015), where the sequence was followed:

Selection of the digital spacer; Selection and calibration in the CT (working length) of the main cone of gutta-percha (Tanari, Manacapuru - AM); Disinfection of gutta-percha cones in 2.5% sodium hypochlorite solution for 10 minutes; Main cone test where visual inspection and tactile criteria were performed since the main cone should

lock in the CT; Drying the flue with absorbent cones # 30, preparing Sealer 26 filling cement (Dentsply / Maillefer, Munich - Germany); Placement of the main cone wrapped in the filling cement; Lateral compaction with digital spacers and placement of accessory cones; Cut the gutta-percha close to the pulp chamber with a heated compactor in a lamp, followed by final vertical compaction with cold pressers.

GROUP II: Hybrid Tagger Technique

In this group, following the Tagger hybrid technique protocol described by Lopes and Siqueira (2015):

Selection and calibration in the CT (working length) of the main gutta-percha cone (Tanari, Manacapuru - AM); Disinfection of gutta-percha cones in 2.5% sodium hypochlorite solution for 10 minutes; Drying the flue with absorbent paper cones # 30, preparing Sealer 26 filling cement (Dentsply / Maillefer, Munich - Germany); Adaptation of the main cone in the root canal in the working length (CT) wrapped in Sealer 26 cement (Dentsply / Maillefer, Munich - Germany); Lateral compaction of the apical segment using accessory cones (Tanari, Manacapuru - AM); Cutting excess gutta-percha outside the root canal; Insertion of the digital endodontic spacer (Dentsply / Maillefer, Ballaigues - Switzerland), followed by the immediate insertion of the compactor in the established space.

The McSpadden 040-21mm condenser (Dentsply / Maillefer, Ballaigues - Switzerland) was attached to a low-rotation contra-angle and inserted into the root canal to the point where it encountered resistance, and then it was retracted about 1mm and turned clockwise. After 1 second, the compactor was driven in an apical direction for 1 to 2 mm, being then removed from the root canal with gentle lateral pressure. After that, the filling mass was compacted at the mouth of the root canal with Schilder condensers (Odous De Deus - Brazil), preceded by the removal of remnants in the pulp chamber. Then, the pulp chamber was cleaned.

GROUP III: Continuous wave technique

This technique was performed in two stages: Downpack and Backfill. The device Termo Pack II (Easy, Belo Horizonte - Brazil) was used, following the manufacturer's recommendations.

Below is the sequence performed following the description of Lopes and Siqueira in 2015 for this technique:

Selection and calibration in the CT (working length) of the FM gutta-percha cone (Tanari, Manacapuru - AM); Disinfection of gutta-percha cones in 2.5% sodium hypochlorite solution for 10 minutes; Drying the flue with absorbent paper cones # 30, preparing Sealer 26 filling cement (Dentsply / Maillefer, Munich - Germany); Positioning of the main cone wrapped in the filling cement in the root canal. Cut the outer portion of the cone with the heated plugger condenser.

1st Stage: Downpack

The plugger condenser was inserted in the thermo condenser, inserted in the canal, heating the gutta-percha until reaching a depth of 5mm below the working length, with a temperature of 200 ° C; After 5 seconds with laterality movements, it was removed from the inside of the root canal, breaking the gutta-percha; The 40/80 condenser instrument (Easy, Belo Horizonte - Brazil) was used to condense the apical plug.

2nd Stage: Backfill

The thermal injector left the gutta-percha preheated to 180 ° C, the metal tip was then selected, being 5 mm from the actual working length; 2/3 of the canal was filled with heated gutta-percha; Condensation of gutta-percha with a Paiva condenser (Gol-gran / Millennium - São Paulo - SP).

After the filling techniques were performed, the dental elements of the three groups were stored in a humid environment (37 ° oven), inside a box with a gauze base moistened for 15 days to allow the cement to set. After these days, the teeth were radiographed through digital radiography (Schick - DMM Health - Brazil) for the quantification of the lateral canals filled in each technique tested in this research.

Analysis of digital images

Digital radiographs were taken in the vestibule-lingual position using digital x-ray (Schick - DMM Health - Brazil). These images were evaluated and the pre-filling of the lateral canals was counted using two previously calibrated examiners. Where, the channels presenting their complete filling (radiopacity of the filling material within the canals) were considered as filled, and the others not completely filled (radiolucency within the canals) as not filled (figure 01).

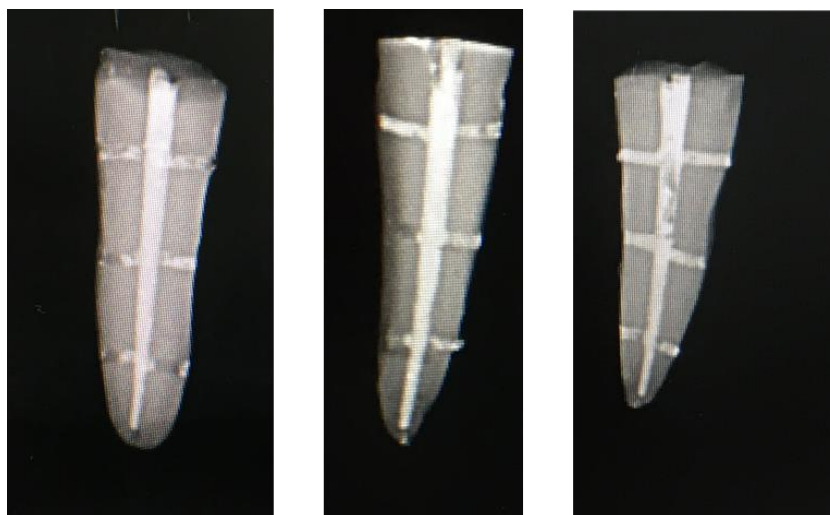


Fig.1: Radiographic images of the filled teeth: A - Lateral compression technique; B - Tagger hybrid technique; C - Continuous wave technique.

Source: Own authorship

STATISTICAL ANALYSIS

The efficacy of the filling of these canals was assessed by means of digital radiography and classified considering the number of simulated canals that were filled with the filling material at different heights. Tables were made from the observation of the radiographs and later the results were submitted to statistical analysis, using the non-parametric Chi-square test, in which the statistical difference was considered when $p < 0.05$, according to the same method

used by Rebouças et al. 2013, when he also evaluated the filling of lateral canals using different techniques.

III. RESULTS

The results showed that the lateral condensation technique presented most of the canals that were not filled (Table 1), and that it presented the largest number of canals in the middle third at the level of 7 mm on the left.

Table 1. Lateral Condensation Technique (Group I) - filling of lateral canals

Teeth	11mm	11mm	7mm	7mm	3mm	3mm
	Left	Right	Left	Right	Left	Right
1	yes	no	yes	no	no	yes
2	no	no	yes	yes	no	no
3	yes	no	yes	yes	yes	yes
4	yes	no	yes	yes	no	no
5	yes	yes	no	no	no	no
6	no	no	no	no	no	no
7	no	yes	no	yes	yes	yes
8	yes	yes	no	yes	no	no
9	no	no	yes	yes	yes	yes
10	yes	no	yes	yes	yes	yes

Source: Own authorship

The hybrid Tagger technique performed better than the lateral condensation technique, with the filling of most canals at the cervical level (Table 2).

Table 2. Hybrid Tagger Technique (Group II) - filling of lateral canals

Teeth	11mm	11mm	7mm	7mm	3mm	3mm
	Left	Right	Left	Right	Left	Right
1	yes	yes	yes	yes	yes	yes

2	yes	yes	no	no	yes	no
3	yes	no	no	yes	yes	yes
4	yes	yes	no	no	yes	yes
5	yes	yes	yes	no	yes	no
6	yes	yes	yes	no	yes	yes
7	yes	yes	yes	no	yes	yes
8	yes	yes	yes	yes	yes	yes
9	yes	yes	yes	no	no	yes
10	yes	yes	yes	yes	yes	no

Source: Own authorship

The continuous wave technique showed the highest frequency of lateral canals filled between the three techniques (Table 3).

Table 3. Continuous Wave Technique (Group III) - filling of lateral canals

Teeth	11mm	11mm	7mm	7mm	3mm	3mm
	Left	Right	Left	Right	Left	Right
1	yes	yes	yes	no	yes	yes
2	yes	yes	yes	yes	yes	yes
3	yes	yes	yes	no	no	yes
4	yes	yes	yes	yes	yes	no
5	yes	yes	yes	yes	yes	no
6	yes	yes	yes	yes	yes	yes
7	yes	no	yes	no	no	no
8	yes	no	yes	yes	yes	yes
9	yes	yes	yes	yes	yes	no
10	yes	yes	yes	no	yes	yes

Source: Own authorship

From these tables, the data were subjected to statistical analysis by the non-parametric Chi-square test. In the comparisons between groups, the lateral condensation technique showed statistically significant differences ($p < 0.05$) when comparing the Tagger hybrid technique only in the apical third (at 3 mm from the apex). There was a

statistically significant difference ($p < 0.05$) in the middle third (at 7 mm from the apex), between the lateral condensation and continuous wave techniques (Table 4). Among the hybrid Tagger and continuous wave techniques, no statistically significant differences were found ($p > 0.05$) (Table 4).

Table 4. Group I x II x III - Comparison between the same variables between groups

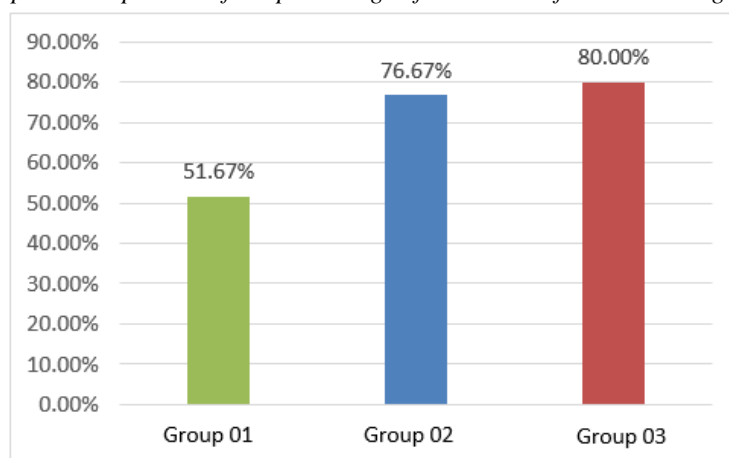
Distance from root apex	Cross	Statistical Significance Level
3 mm	Group I x Group II	$p = 0.0000^*$
3 mm	Group I x Group III	$p = 0.4167$
3 mm	Group II x Group III	$p = 0.0794$
7 mm	Group I x Group II	$p = 0.1786$
7 mm	Group I x Group III	$p = 0.0174^*$
7 mm	Group II x Group III	$p = 0.1190$
11 mm	Group I x Group II	$p = 0.4762$
11 mm	Group I x Group III	$p = 0.0666$
11 mm	Group II x Group III	$p = 0.6250$

* Represents statistically significant difference ($p < 0.05$)

Source: Own Authorship

Among the three groups, group III (continuous wave technique) showed the highest percentage of filled canals (Graph 1).

Graph 1. Comparison of the percentage of side canals filled between groups



Source: Own Authorship

Group I (lateral condensation technique), showed the lowest filling frequency among the other techniques performed here.

IV. DISCUSSION

It is significant to emphasize the importance of the root canal filling stage, considering that the final objective is the elimination of empty spaces previously occupied by the dental pulp, these spaces when not filled correctly can serve as niches for the proliferation of microorganisms. (Lopes and Siqueira, 2015). It is therefore substantial that the dentist increasingly acquires knowledge about the techniques and materials used in this phase of endodontic therapy, as it is a broad subject, and it is relevant to highlight the importance of research on this theme.

The complicated morphology of the root canal system, where the lateral and accessory canals are found, constitutes communication routes between the interior of the root canal and the periodontium. Therefore, several studies such as that by Silva et al. (2013) for example, which aims to address issues such as sanitation and the proper filling of these branches, has gained space within endodontics, considering that there are different techniques that are modified and created all with the intention of seeking the success of endodontic treatment.

The evaluation method chosen to be used in the present study was digital radiography. As mentioned by Rebouças et al (2013), greater speed and fidelity of the image are characteristics of digital radiography, thus being a method of comparative evaluation between filling techniques, as it is possible to have a good view of the distribution of the material. obturator along the entire length of the root canal.

The choice of using extracted human teeth instead of teeth or resin blocks was due to the fact that they

provide greater proximity to the anatomical variations of the root canal system. The drill used to make the simulated lateral canals was the LN (Dentsply / Maillefer, Ballaigues - Switzerland), because it has already been used in other studies such as that by Oliveira et al. (2018), and the ease of making the canals through these drills.

The simulation of simulated lateral canals has already been carried out in other studies using different methods, such as K # files with modified cutting tips, (MORGENTAL et al., 2008; RAYMUNDO et al., 2005), different from the present study in which a drill was used LN, being also a method already used in other research (Oliveira et al., 2018) aiming at the same objective. Notwithstanding, despite the different methods of making the simulated lateral canals, no research was found in the literature during the course of this study to make lateral canals in order to know which method would be the most suitable for this type of research.

The instrumentation technique chosen to be performed in this work was the rotary system through ProTaper Universal files (Dentsply / Maillefer, Ballaigues - Switzerland), as it is considered a fast execution technique in comparison with manual instrumentation techniques as mentioned by Lopes and Siqueira (2015), also taking into account the amount of teeth used in the research and the time in which we had to carry out the test. Other advantages, such as a greater taper and enlargement of the root canal, were taken into account, as it is a factor that favors, according to the same author, the selection of the main cone and the three-dimensional filling of the root canal.

The irrigation solutions have the function to contribute to the sanitation of the root canal through the antibacterial action and also contribute to the lubrication of the canal during the instrumentation, thus promoting an environment conducive to a better adhesion of the filling materials. Therefore, the most used protocols in the literature preconized the use of sodium hypochlorite (Neelakantan et al., 2015), the irrigating solution chosen to be used in this research was 2.5% sodium hypochlorite.

In order to have a greater standardization of the samples, the same filling material was used in all groups: gutta-percha cones (Tanari, Manacapuru - AM) and Sealer 26 filling cement (Dentsply / Maillefer, Munich - Germany). The insertion method of the obturator cement was the same in all groups so that it would not influence the results, being the insertion technique with the main cone.

The AH plus cement is considered the gold standard of endodontics, standing out for its characteristics such as radiopacity (LOPES and SIQUEIRA, 2015). However, the cement used in this research was Sealer 26, which is also considered a cement with excellent characteristics, contributing to a good sealing of the root canal branches. Despite this, one cannot rule out the hypothesis that the characteristics of the filling cement influence the flow and radiopacity of the filled canals.

The filling insertion technique can significantly influence the filling of lateral canals. As shown by Oliveira et al. in 2018, when he compared the insertion techniques of obturator cement in relation to the obturation of lateral canals, the one that showed the best results the insertion through the gutta-percha cone. Therefore, this is also the most used method in endodontics, being the one of choice in carrying out this research.

During instrumentation of the root canal, the formation of considerable amounts of cut remains consisting of very small particles of mineralized collagen matrix may occur, which we know as smear layer. The removal of this layer is necessary so that the adhesion of the filling material is not compromised, since the dentinal tubules will be properly unobstructed and properly cleaned. Therefore, the use of EDTA at 17% is considered quite effective (Nunes et al. 2008; Esteves et al. 2013), in the research EDTA17% was used together with ultrasonic activation in order to enhance smear removal layer, following the protocol of (Van der Sluis et al. 2010).

As emphasized by Van der Sluis et al. (2010) in their study, the use of passive ultrasonic irrigation (PUI) is important since it results in an increase in the temperature of the irrigant, bringing better results, with a better ability to dissolve tissue, remove tissue pulp, bacteria and smear layer when sodium hypochlorite is used as an irrigant.

Although the current filling techniques that recommend the use of thermoplasticized gutta-percha, are gaining space due to obtaining satisfactory results in filling the root canal system, the lateral compression technique remains the most used in recent years, being considered a technique standard for the comparison of filling between root canals, as highlighted by Rebouças et al (2013) and Lopes and Siqueira (2015).

Nevertheless, the lateral compaction technique does not promote a homogeneous mass such as that which we are able to obtain in the execution of the hybrid Tagger and continuous wave techniques, thus making the latter two promote a more three-dimensional filling of the root canal system. In the technique of lateral condensation, the filling of branches such as the lateral canals and accessories takes place by pressing the gutta-percha cone to the walls of the conduit, promoting the flow of the filling cement into the canals. As mentioned by some authors such as Miranda et al. (2013) and which is proven in research such as that of Brosco et al. (2003) and Silva et al. (2013) in which they demonstrate a better obturation capacity of lateral canals through techniques that use thermoplasticized gutta-percha.

Bramante et al. in 1999, he evaluated the filling of lateral canals using the technique of placing cement in the canal, using the standard technique of lateral compaction in the filling stage, the insertion of the filling cement with the gutta-percha cone showed satisfactory results when compared to others methods. In 2018 Oliveira et al. the same conclusion was also reached, with this it can be inferred that in this research the insertion method of filling cement may have contributed to the filling of the lateral canals, especially in the lateral compaction technique, considering that in the hybrid techniques of Tagger and wave continuous it was found that the canals were filled with gutta-percha together with endodontic cement.

From the results presented in this research, it was found that obturation using the continuous wave technique showed a higher frequency of obturation of the lateral canals in comparison with the hybrid techniques of Tagger and lateral compaction, in agreement with the study by Rebouças et al. in 2013, where he points out that in the lateral condensation technique the filling of the lateral canals was only due to the filling cement, which also occurred in this study. However, in the studies of Lima, Porto and Santos in 2004, it was found that between the techniques of continuous wave and lateral condensation the sealing capacity of the root canal was similar.

The hybrid technique of Tagger as proven by some authors (MORGENTAL et al., 2008; Raymundo et al., 2005), promotes a good filling of the lateral canals and is a relatively easy technique to perform, agreeing with this

study, in view that it presented better filling capacity of the lateral canals compared to the lateral condensation technique.

The Tagger continuous and hybrid wave techniques did not show statistically significant differences regarding the filling of simulated lateral canals in this study, also agreeing with the results found by Rebouças et al. in 2013, and Raymundo et al. in 2005.

Many of the studies, even using different methods of making artificial lateral canals, brought results similar to those found in this study. (MORGEN-TAL et al., 2008; RAYMUNDO et al., 2005; REBOUÇAS et al., 2013).

There is still little evidence of studies similar to this one, and because it is an in vitro study, it is worth highlighting the need for more research in order to conflict and consolidate the results obtained here.

V. CONCLUSION

It can be concluded from the results presented in the research that the Continuous Wave technique presented better capacity to fill simulated lateral canals, followed by the Tagger hybrid technique and lateral condensation. None of the three techniques was able to fill all the simulated side canals.

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