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Influence of Sealer Placement Technique on the Quality of Root Canal Filling by Lateral Compaction or Single Cone

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The aim of this study was to evaluate the influence of the sealer placement technique on the quality of root canal filling using Lateral Compaction (LC) or Single Cone (SC). In order to do that, 60 mesial roots of mandibular first molars were prepared and divided into 2 groups (n=30), according to the filling technique: LC and SC. Each group was subdivided into 3 subgroups (n=10), according to the different sealer placement methods: A: Master gutta-percha (GP) cone; B: Lentulo spiral; C: File. The roots were sectioned at 2, 4 and 6 mm from the apex and photographed with the aid of a digital microscope. Then, areas of GP, endodontic sealer and voids were measured, and these data were subjected to statistical analysis. LC technique showed no statistically difference ($p>0.05$) in the percentage of GP area, sealer and voids between the subgroups at any of the three levels. After use of SC, higher percentages of sealer area were found at all levels ($p<0.01$) when the sealer was placed with a file. At 2 mm, higher percentage of void areas ($p<0.05$) was observed when the cone was used, lower percentage with K-file and the lowest percentage with Lentulo. At 4 mm, cone showed higher percentage of void areas ($p<0.05$). At 6 mm, there were no significant differences ($p>0.05$) between the three methods. Considering these results, using an instrument for sealer placement was important in the SC technique to reduce voids. Regarding LC, the sealer placement techniques provided similar results.

Key Words: Endodontics, gutta-percha, microscopy, obturation, sealing quality.

Introduction

Successful endodontic treatment is achieved by proper cleaning, shaping and seal of the root canal system. A proper filling prevents the penetration of microorganisms and their toxins, allows for periapical repair and prevents reinfection (1).

The combination of gutta-percha (GP) and an endodontic sealer is usually employed for root canal filling. Furthermore, not only does this combination contribute to an effective filling, but also the dimensional stability of the endodontic sealer (2), the filling technique (3,4), and the sealer placement method (5). Thus, the filling process can be optimized by choosing a high-performance sealer combined with GP, an adequate filling technique and a more efficient sealer placement method.

Several methods have been used for placing endodontic sealer into the root canal, including files and reamers, GP cones, paper points, Lentulo spirals, the Max-i-Probe Delivery System, ultrasonic files, among others. Said et al. (5), Hall et al. (6) and Wiemann and Wilcox (7), in their studies, used Lateral Compaction (LC) and compared different placement techniques; all of them found similar results, concluding that these different placement techniques provide comparable seals. However, Kahn et al. (8) used LC and compared six sealer placement methods, and concluded that the Lentulo spiral and the Max-i-Probe Delivery System were the most effective methods, followed by ultrasonic and sonic files; and the least effective methods were paper points and K-files. Considering these different results obtained in studies related to placement techniques, other evaluations are necessary to determine whether or not some placement techniques are more effective than others. In addition, to address this question more accurately, it is also important to use more than one filling technique, in order to determine whether the filling technique causes differences in the results, even when the same placement methods are used.

Among the most varied filling techniques, the Single Cone (SC) has been used after root canal preparation with rotatory instruments, not only because it allows better adaptation in three-dimensional preparation (9), but especially because it reduces the time spent on lateral compaction of GP (10). On the other hand, LC has been the most commonly applied root canal filling technique. Moreover, it is a standard procedure for the evaluation of other techniques (11).

There are many parameters for evaluating the quality of root canal seal, such as radiographic visualization (12) or observation of computed tomography images (13,14). One method to evaluate the quality of root canal seal is to determine the area of GP in the root canal filling in relation to the amount of sealer or empty spaces, by microscopic

observation of the root cross-sections (15-17). Furthermore, it is possible to establish a ratio between theareas with filling material and the empty areas.

Since there are different techniques for filling root canals and several methods for inserting the sealer into them, comparative evaluations between placement methods are fundamental for optimizing endodontic filling. Moreover, to obtain more reliable results, it is essential to use more than one filling technique in order to accurately establish that one sealer placement method is always more effective than the others. Considering the foregoing, the aim of this study was to compare the percentages of areas of GP, endodontic sealer and voids in root canal fillings performed with three sealer placement methods and two filling techniques. It was proposed that after the root canals were prepared with ProTaper Universal System, the sealer would be inserted into them using a master GP, a rotatory Lentulo spiral ora K-file, and then SC or LC would be performed to obturate them. So the null hypothesis evaluated in this study was that there would be no difference in the root filling quality when the method of placing the sealer was changed.

Material and Methods

Specimen Selection and Biomechanical Preparation

After ethics committee approval of the study (Process #21/10), 30 extracted human mandibular first molars with curvature angles from 30 to 40 degrees were selected. Their dental crowns and distal roots were removed with a diamond-coated disc, and the mesial root length was standardized at 14 mm. Thus, only the mesial roots of each specimen remained, totaling 30 roots and 60 root canals with distinct foramens.

A size 15 K-file (Maillefer Instruments, Ballaigues, Switzerland) was introduced into the root canals to the real length of the tooth in order to verify the apical diameter of the canal. The apical preparation was determined at 1 mm short of the apex.

The root canals were prepared according to the crown-down technique, with ProTaper Universal files (Dentsply, Petrópolis, RJ, Brazil), from the SX instrument to the F2 (size 25, 0.08 taper). The same instrument was only used for 6 specimens, and then discarded. At each change of instruments, the root canal was copiously irrigated with 1% sodium hypochlorite solution (Biodinâmica Química e Farmacêutica Ltda, Ibiporã, PR, Brazil). After root canal instrumentation, a size 15 K-file was introduced in the apical foramen to eliminate dentin residues resulting from the biomechanical preparation.

After this, the root canals were irrigated with 1% sodium hypochlorite solution and dried with paper points (Dentsply). Next, the canals were filled with EDTA solution (Odahcam; Herpo Ltda, Rio de Janeiro, RJ, Brazil) and irrigated again with 1% sodium hypochlorite solution, then dried with paper points.

The specimens were randomly distributed into 2 groups of 30 root canals each, according to the filling technique: LC and SC. Both groups were subdivided into 3 subgroups (A, B and C) with 10 root canals each, according to the method used to place the endodontic sealer into the canals when filling began: A: sealer placement with the master GP cone; B: sealer placement using rotatory Lentulo spiral, before the introduction of the master GP cone; C: sealer placement with a K-file, before the introduction of the master GP cone.

Root Canal Filling with LC and SC

For LC, a 2%-tapered standard GP cone (Maillefer Instruments) was selected and calibrated with a ruler, then introduced into the root canal. Afterwards, radiographs were taken to confirm the distance of approximately 1 mm between the root apex and the apical extension of the GP cone. In each group, the cones were removed and the sealer material was inserted into the root canals using the different techniques:

A: The GP cone was coated with endodontic sealer and immediately introduced into the root canal to the length of the biomechanical preparation.

B: A size 25 rotatory Lentulo spiral (Maillefer Instruments) was interlocked to the hand piece and coated with endodontic sealer. The Lentulo was introduced into the root canal at 2 mm from the biomechanical preparation and removed slowly, rotating slowly and uninterruptedly with 300 rpm and 1 Ncm torque. The selected GP cone was coated with endodontic sealer and introduced into the root canal until the length of the biomechanical preparation.

C: A size 25 K-file was coated with endodontic sealer and introduced into the root canal with oscillatory movements to the length of the biomechanical preparation. The selected GP cone was coated with endodontic sealer and introduced into the root canal to the length of the biomechanical preparation.

In subgroups A, B and C, after performing these procedures, a spreader B (D1 0.25, taper 0.03) was introduced alongside the master cone with oscillatory movements, achieving the maximum apical load of 2 Kg (18). The spreader was kept in position for 15 s and then it was removed by rotating it twice 360° in the counterclockwise direction and once 360° in the clockwise direction. Next, a standard fine accessory cone was placed in the root canal. This procedure was repeated until 8 to 10 accessory cones were placed, in order to complete the filling.

For filling with SC, a F2 GP cone was selected (Maillefer Instruments), adjusted to the length of the biomechanical

preparation. After this, radiographs were taken to confirm the distance of approximately 1 mm between the root apex and the apical extension of the GP cone. The cones were removed and the sealer was inserted into the root canals with different techniques for each group (A: the cone itself, B: Lentulo spiral, and C: K-file).

After both LC and SC techniques were performed on the specimens, a heated plugger was used to remove the coronal excess of GP with no further vertical compaction. Then vertical compaction of the GP was performed with a cold stamper and the cervical third of the canal was sealed with temporary/provisional cement.

Once the filling was concluded, the teeth were radiographed again to ensure the integrity and the extension of the filling.

Finally, the specimens were stored for 7 days at 37° and air humidity of 100%, in order to ensure the complete setting of the endodontic sealer.

Root Sectioning and Image Capture

The roots were transected with a diamonded disc (Isomet, Buehler, Germany). Transections in the plane of curvature of the roots were made at 2, 4 and 6 mm from the root apex and taken to a digital microscope (Olympus Optical do Brasil, São Paulo, SP, Brazil). The resulting images were transferred to Image Tool 3.0 Software, in order to obtain the areas of gutta-percha, endodontic sealer and voids.

Statistical Analysis

The Graph Pad Software program (San Diego, CA, EUA) was used to perform statistical analysis. ANOVA and Bonferroni tests were used to analyze the percentages of sealer and GP areas, according to the method by which the endodontic sealer was placed; to evaluate the percentages of void areas, Kruskall-Wallis and Dunn tests were used, at a level of significance of 5%.

Results

For the SC technique, data analysis showed statistically significant difference ($p<0.05$) only in the percentage of GP area at 6 mm (Fig. 1A). The highest percentage was observed when the master cone was used to place the sealer. The percentage of endodontic sealer within the root canals (Fig. 1C) differed significantly ($p<0.01$) when placements by means of cone and K-file were compared, or when comparisons between insertions by means of cone and Lentulo were made. The percentage of endodontic sealer area showed no statistical difference ($p>0.01$) when the insertions by means of K-file and Lentulo were compared. Significantly lower percentages of endodontic sealer within the root canal at the three levels (2, 4 and 6 mm) were observed, when sealer was placed using a GP cone (Fig. 1C). For the percentage of voids (Table 1) at 2 mm, statistically significant differences ($p<0.05$) were found among the three sealer placement methods; in addition, a higher percentage was found when gutta-percha coating was applied. At 4 mm, there was statistically significant difference only when the sealer was placed with the cone. At 6 mm, no significant differences were found between the methods. The lowest incidence of voids was observed when the Lentulo spiral was used to place the sealer.

For the LC technique, data analysis showed no statistically significant difference ($p<0.05$) between the percentages of GP (Fig. 1B) and endodontic sealer areas (Fig. 1D) or area of voids (Table 2), with any sealer placement method, at any of the three levels (2, 4 and 6 mm).

Figure 2 is a composite figure of representative images of LC and SC at the three levels from the root apex.

Discussion

In this study, the percentage of GP, endodontic sealer and void areas in root canal filling was evaluated. The root canals were instrumented with ProTaper Universal System, a widely used rotatory system that allows quick instrumentation, because of its high cutting performance (19). The canals were filled using the LC and SC techniques and the endodontic sealer was placed by means of the master GP cone, Lentulo spiral or K-file.

Researches with the aim of comparing different filling techniques and endodontic sealers usually use single rooted teeth, which do not show many anatomic differences, making it easier to standardize the specimens (3). However, the results obtained with the use of these teeth cannot be considered true for molar root canals with atresia, curves and complex anatomy, because they have areas that are difficult to gain access to and clean (20). Thus, the mesial canals of mandibular molars must be used for in vitro evaluations of materials and sealing techniques, because they effectively show more similarity to clinical reality (3). Therefore, the mesial roots of mandibular first molars were used in this study.

The chosen sealer was AH Plus, nowadays strongly recommended for its excellent physicochemical and biological properties (21). It has low solubility and long-term dimensional stability (22,23), so that the use of a larger quantity of sealer must be accepted, in spite of the recommendation that the lowest possible percentage of sealer should be used in fillings (24).

In this study, when LC was performed, no significant difference in the percentages of filling material and voids could be observed, despite different sealer placement methods being applied. Thus, the quality of the filling was similar, whatever the method by which the endodontic

sealer was placed in the canal. The LC results are similar to those reported in previous studies (5-7) in which only LC filling technique was used. The match between these results may confirm the reason that lies behind the wide use of and preference for LC by the professionals.

When SC was used to place the endodontic sealer, a larger quantity of GP could be observed at 6 mm. This may be due to the greater strength and higher pressure on this level at the time of lateral compaction.

Furthermore with SC, the percentage of endodontic

Table 1. Percentages of voids between sealer placement methods at levels of 2, 4 and 6 mm from the root apex, using the Single Cone technique

Sealer placement methods	2 mm			4 mm			6 mm		
	Median	Q1-Q3	Min-max	Median	Q1-Q3	Min-max	Median	Q1-Q3	Min-max
Gutta-percha cone	7.67[a]	5.0-12.5	0.0-20.9	5.06[a]	2.4-7.95	0.0-17.95	0.0[b]	0.0-0.0	0.0-6.0
Lentulo	0.0[b]	0.0-0.0	0.0-3.57	0.0[b]	0.0-0.49	0.0-3.03	0.0[b]	0.0-0.0	0.0-0.0
File	1.56[c]	0.0-10.8	0.0-17.5	0.0[b]	0.0-3.67	0.0-8.51	0.0[b]	0.0-0.0	0.0-0.0

Different superscript letters in the same column indicate statistically significant differences (p<0.05).

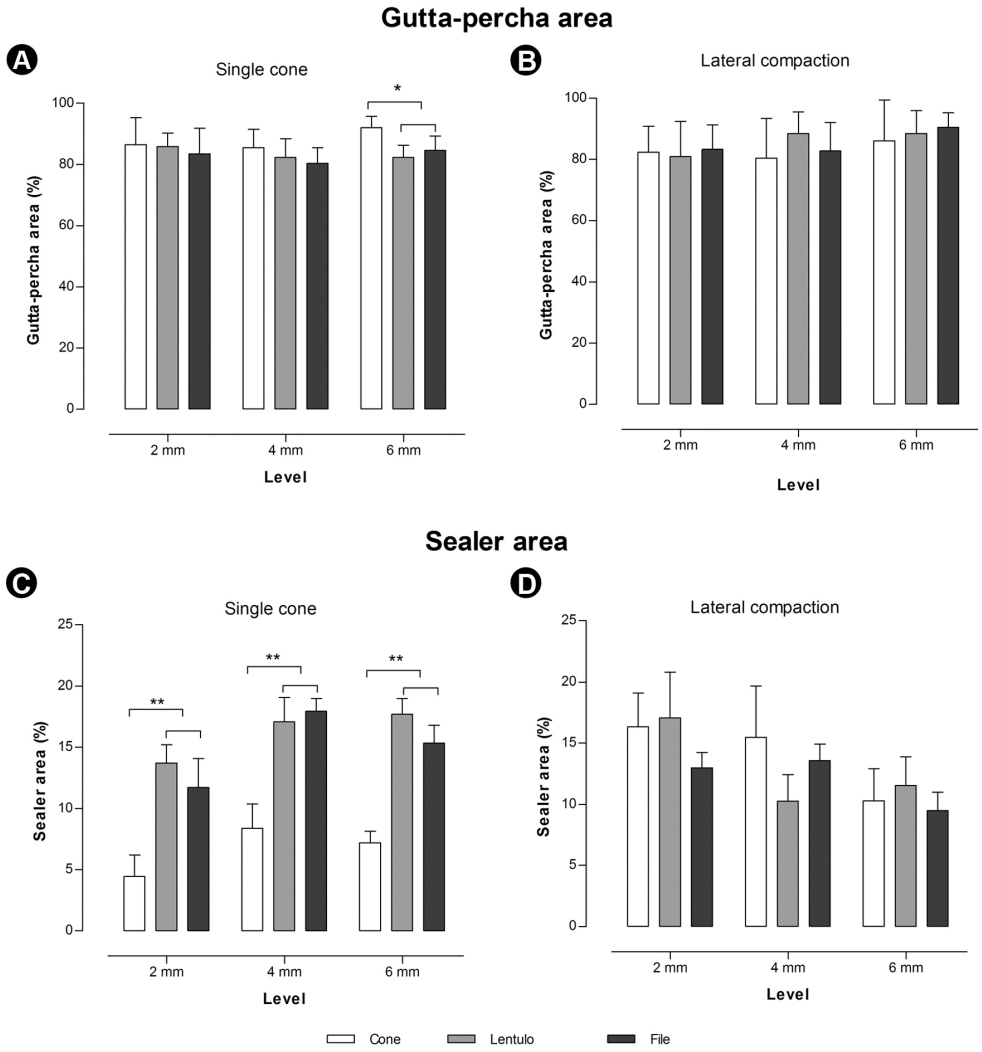

Figure 1. Percentage of GP Area at 2, 4 and 6 mm levels with the three sealer placement methods, using SC (A) and LC (B); percentage of endodontic sealer area at 2, 4 and 6 mm levels with the three sealer placement methods, using SC (C) and LC (D). *Statistical significance: p<0.05. **p<0.01.

sealer at 2 and 4 mm was significantly lower when it was placed with the use of the master GP cone. It is possible that this occurred because the endodontic sealer sticks to the root canal walls when the GP cone is inserted. Thus, the endodontic sealer is simply unable to adequately reach the apical and medium regions when the cone is used to insert the sealer. The percentage of sealer area was significantly higher when the K-file or Lentulo spiral was used for sealer placement. Furthermore, there was a significantly smaller quantity of voids. Root canal preparation with rotatory instruments gives root canals a cylindrical or frequently an oval shape, so that empty spaces may be found after filling has been completed, especially in the middle and cervical thirds (25). Therefore, it is evident that it is necessary to place the sealer with an instrument that is capable of reaching the full length of the canal before the master GP cone is introduced. This method reduces significantly the occurrence of voids, especially in the apical region, ensuring more hermetic endodontic canal fillings.

It is also important to emphasize that all results obtained in the present study showed wall coverage percentages of over 90%, with both LC and SC. Thus, it suggests that SC is applicable only if an instrument is used for sealer placement without loss in the effectiveness of the treatment.

When the LC technique was used, the sealer placement method did not interfere in the quality of the filling. Thus, in this technique, the sealer can be placed with any of the three methods. Otherwise, the SC technique promoted a

Table 2. Percentages of voids between sealer placement methods at 2, 4 and 6 mm from the root apex, using the Lateral Compaction technique

Sealer placement methods	2 mm			4 mm			6 mm		
	Median	Q1-Q3	Min-max	Median	Q1-Q3	Min-max	Median	Q1-Q3	Min-max
Gutta-percha cone	0.0	0.0-0.8	0.0-10.34	1.06	0.0-11.82	0.0-13.04	0.0	0.0-0.0	0.0-0.0
Lentulo	0.0	0.0-2.9	0.0-13.95	0.0	0.0-2.63	0.0-6.98	0.0	0.0-0.0	0.0-0.0
File	0.0	0.0-4.9	0.0-12.50	0.0	0.0-3.75	0.0-26.92	0.0	0.0-0.0	0.0-0.0

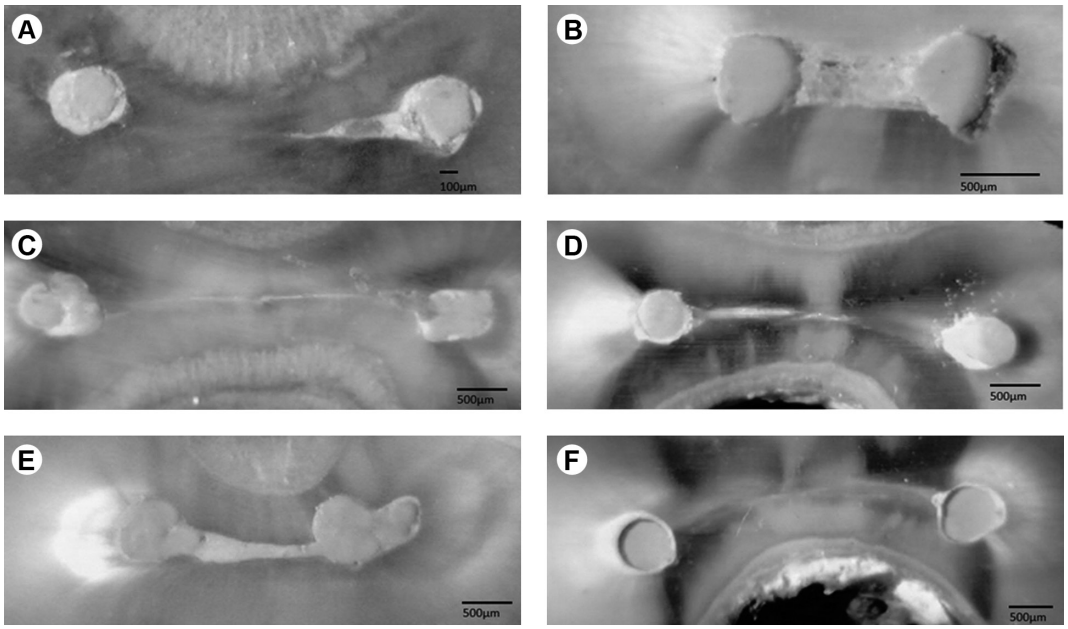

Figure 2. A, C and E are representative images of LC and B, D and F of SC, at the three levels from the root apex Because of the different image zooms, the rulers of the figures differs of one another. A: LC at 2 mm: Presence of voids when the endodontic sealer is placed only by means of the master gutta-percha cone. B: SC at 2 mm: Presence of voids when the endodontic sealer is placed by means of the master gutta-percha cone. C: LC at 4 mm: Absence of voids by the good distribution of the endodontic sealer when an instrument is used for the placement. D: SC at 4 mm: Absence of voids by the good distribution of the endodontic sealer when an instrument is used for the placement. E: LC at 6 mm: Absence of voids and isthmus filling when the endodontic sealer is placed with an instrument. F: SC at 6 mm: Gutta-percha cone well-adapted and absence of voids.

significant quantity of voids in the root filling when only the master GP cone was used to place the endodontic sealer. Therefore, sealer placement with a K-file or Lentulo before the introduction of GP cone is essential. These instruments can effectively raise the percentage of endodontic sealer area and reduce the percentage of void areas.

Resumo

O objetivo deste estudo foi avaliar a influência das técnicas de inserção de cimento endodôntico na qualidade da obturação, usando Compactação Lateral Ativa (CLA) e Cone Único. Para tal, 60 raízes mesiais de primeiros molares inferiores foram preparadas e divididas em 2 grupos (n=30), de acordo com a técnica de obturação: CLA e Cone único. Cada grupo foi subdividido em 3 subgrupos (n=10), de acordo com as diferentes técnicas de inserção aplicadas: A - Cone de guta-percha principal; B - Lentulo; C - Lima. As raízes foram seccionadas a 2, 4 e 6 mm do ápice e fotografadas com microscópio digital. Então, as áreas de guta-percha, cimento endodôntico e falhas foram medidas e tais dados foram submetidos à análise estatística. CLA não revelou diferenças estatisticamente significantes (p>0,05) nas porcentagens das áreas de guta-percha, de cimento endodôntico e de falhas, em nenhum dos grupos ou níveis de corte. Com a aplicação da técnica do Cone Único, maiores porcentagens de área de cimento foram encontradas nos três níveis (p<0,01) quando este foi inserido por meio de uma lima. Aos 2 mm, a maior porcentagem de área de falhas (p<0,05) foi observada quando o cone foi utilizado. Uma porcentagem menor foi encontrada quando foi utilizada a lima; e a menor porcentagem foi observada com o Lentulo. Aos 4 mm, a inserção por meio do cone apresentou maior porcentagem de falhas (p<0,05). Aos 6 mm, não houve diferença estatisticamente significante (p>0,05) entre os três métodos. Considerando esses resultados, foi importante o uso de um instrumento para a inserção do cimento quando a técnica do Cone Único foi aplicada. Já com CLA, qualquer técnica de inserção de cimento apresentou resultados similares.

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References

1. Estrela C, Holland R, Estrela CRA, Alencar AHG, Sousa-Neto MD, Pécora JD. Characterization of successful root canal tratment. Braz Dent J 2014;25:3-11.
2. Nikhil V, Singh R. Confocal laser scanning microscopic investigation of ultrasonic, sonic and rotatory sealer placement techniques. J Conserv Dent 2013;16:294-299.
3. Marciano MAS, Ordinola-Zapata R, Cunha TVRN, Duarte MAH, Cavenago BC, Garcia RB. Analysis of four gutta-percha techniques used to fill mesial root canals of mandibular molars. Int Endod J 2011;44:321-329.
4. Souza EM, Wu MK, van der Sluis LW, Leonardo RT, Bonetti-Filho I, Wesselink PR. Effect of filling technique and root canal area on the percentage of gutta-percha in laterally compacted root fillings. Int Endod J 2009;42:719-726.
5. Said HM, Bakar WZW, Farea M, Husein A. The effect of sealer placement techniques on sealing ability: an *in vitro* study. J Conserv Dent 2012;15:257-260.
6. Hall MC, Clement DJ, Dove SB, Walker WA. A comparison of sealer placement techniques in curved canals. J Endod 1996;22:638-642.
7. Wiemann AH, Wilcox LR. *In vitro* evaluation of four methods of sealer placement. J Endod 1991;17:44-47.
8. Kahn FH, Rosenberg PA, Schertzer L, Korthals G, Nguyen PNT. An *in vitro* evaluation of sealer placement methods. Int Endod J 1997;30:181-186.
9. Cavenago BC, Duarte MAH, Ordinola-Zapata R, Marciano MA, del Carpio-Perochena AE, Bramante CM. Interfacial adaptation of an epoxy-resin sealer and a self- etch sealer to root canal dentin using the System B or the single cone technique. Braz Dent J 2012;23:205-211.
10. Tasdemir T, Yesilyurt C, Ceyhanli KT, Celik D, Kursat ER. Evaluation of apical filling after root canal filling by 2 different techniques. J Can Dent Assoc 2009;75:201-201.
11. Bjorndal L, Reit C. The adoption of new endodontic technology amongst Danish general dental practitioners. Int Endod J 2005;38:52-58.
12. Tanomaru-Filho M, Luis MR, Leonardo MR, Tanomaru JM, Silva LA. Evaluation of periapical repair following retrograde filling with different root-end filling materials in dog teeth with periapical lesions. Oral Surg Oral Med Oral Pathol 2006;102:27-32.
13. Carvalho-Sousa B, Almeida-Gomes F, Carvalho PRB, Ferreira CM, Gurgel-Filho ED, Albuquerque DS. Filling lateral canals: evaluation of different filling techniques. Eur J Dent 2012;4:51-56.
14. Chokkalingam M, Ramaprabha M, Kandaswamy D. Three-dimensional helical computed tomographic evaluation of three obturation techniques: *in vitro* study. J Conserv Dent 2011;14:273-276.
15. De-Deus GA, Maniglia-Ferreira C, Gurgel-Filho ED, Paciornik S, Machado ACR, Coutinho-Filho T. Comparison of the percentage of gutta-percha-filled area obtained by Thermafil and System B. Aust Endod J 2007;33:55-61.
16. Rodrigues A, Bonetti-Filho I, Faria G, Andolfatto C, Berbert FLCV, Kuga MC. Percentage of gutta-percha in mesial canals of mandibular molar obturated by Lateral Compaction or Single Cone techniques. Microsc Res Tech 2012;2:1-4.
17. Zapata RO, Bramante CM, Graeff MS, Del Carpio Perochena A, Vivan RR, Camargo EJ, et al.. Depth and percentage of penetration of endodontic sealers into dentinal tubules after root canal obturation using a lateral compaction technique: a confocal lasers canning microscopy study. Oral Surg Oral Med Oral Pathol 2009;108:450-457.
18. Wu MK, de Groot SD, van der Sluis LW, Wesselink PR. The effect of using an inverted master cone in a lateral compaction technique on the density of the gutta-percha fill. Oral Surg Oral Med Oral Pathol 2003;96:345-350.
19. Romania C, Beltes P, Boutsioukis C, Dandakis C. *Ex-vivo* area-metric analysis of root canal obturation using gutta-percha cones of different taper. Int Endod J 2009;42:491-498.
20. Carr GB, Schwartz RS, Schaudinn C, Gorur A, Costerton JW. Ultrastructural examination of failed molar retreatment with secondary apical periodontitis: an examination of endodontic biofilms in an endodontic retreatment failure. J Endod 2009;35:303-309.
21. Tanomaru-Filho M, Tanomaru JMG, Leonardo MR, Silva LAB. Periapical repair after root canal filling with different root canal sealers. Braz Dent J 2009;20:389-395.
22. Borges RP, Sousa-Neto MD, Versiani MA, Rached-Júnior FA, De-Deus G, Miranda CE, et al.. Changes in the surface of four calcium silicate-containing endodontic materials and an epoxy resin-based sealer after a solubility test. Int Endod J 2012;45:419-428.
23. Flores DS, Rached-Júnior FJ, Versiani MA, Guedes DF, Sousa-Neto MD, Pécora JD. Evaluation of physicochemical properties of four root canal sealers. Int Endod J 2010;44:126-135.
24. Weiss MV, Parashos P, Messer HH. Effect of obturation technique on sealer cement thickness and dentinal tubule penetration. Int Endod J 2004;37:653-663.
25. Wu MK, Kast'akova A, Wesselink PR. Quality of cold and warm gutta-percha fillings in oval canals in mandibular premolars. Int Endod J 2001;34:485-491.

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