Apical seal comparison of low-temperature thermoplasticized gutta-percha technique and lateral condensation with two different master cones

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ABSTRACT

Aim: To compare the apical sealing in mesio-buccal canals of extracted molars obturated with low-temperature thermoplasticized gutta-percha or cold lateral condensation techniques using a .06 or a .02 mm/mm tapered gutta-percha master cone. The secondary aim was to evaluate the depth of spreader penetration in root canals using a .06 or a .02 mm/mm tapered gutta-percha master cone.

Methodology: Forty-four mesio-buccal curved canals (25-40º) were instrumented with .06 nickel-titanium rotary instruments and randomly distributed into two control groups (n=4) and three experimental groups (n=12) for obturation by the Ultrafil® 3D system or by cold lateral condensation with .06 or .02 tapered master cone. Canal sealer AH-Plus® was used. The depth of spreader penetration was recorded in millimetres. Roots were covered with two layers of nail polish, immersed in India ink for 7 days, transversally sectioned and examined with a stereomicroscope. Student's t test was used to determine whether there was a difference in spreader penetration between groups. Kruskal-Wallis test was used to determine whether there was a difference in leakage.

Results: There were no differences among the three groups (p=0.396), which showed a very similar mean microleakage (0.42, 0.75 and 0.42). The difference in spreader penetration between the groups filled by cold lateral condensation was significant (p=0.001)

Conclusion: The Ultrafil® 3D system and cold lateral condensation techniques with .06 or .02 tapered master cones were equally effective in the apical sealing of curved canals. The spreader penetrated deeper using a .02 mm/mm tapered gutta-percha master cone.

Key words: *Root canals filling, cold lateral condensation, thermoplasticized gutta-percha.*

RESUMEN

Objetivo: comparar el sellado apical en conductos mesio-vestibulares de molares obturados con gutapercha termoplastificada a baja temperatura o con técnica de condensación lateral usando un cono maestro de gutapercha de conicidad .06 o .02. Como objetivo secundario se evaluó la penetración del espaciador en los conductos cuando se utilizó un cono de conicidad .02 o .06.

Metodología: cuarenta y cuatro conductos mesio-vestibulares curvos (25-40º) fueron preparados con instrumentos rotatorios del niquel-titanio de conicidad .06 y distribuidos aleatoriamente en dos grupos control (n=4) y tres grupos

experimentales (n=12) para obturarlos con el sistema Ultrafil® 3D o técnica de condensación lateral de gutapercha en frío con conos maestros de conicidad .06 o.02. AH-Plus fue utilizado como cemento sellador. La profundidad de penetración del espaciador fue registrada en milímetros. Las raíces fueron cubiertas con dos capas de barniz de uñas, sumergidas en tinta china durante 7 días, seccionadas transversalmente y examinadas con un estereomicroscopio. Para determinar si existían diferencias en la penetración del espaciador entre grupos se utilizó el test de la T de Student. La prueba de Kruskal-Wallis fue utilizada para determinar si existían diferencias en la penetración del tinte.
Resultados: no hubo diferencias en la microfiltración entre los tres grupos de estudio (p= 0.396), que mostraban una media muy similar (0.42. 0.75 y 0.42). La comparación de la profundidad de penetración del espaciador en los grupos obturados mediante condensación lateral fue significativamente superior cuando se usó un cono de conicidad .02 (p= 0.001).
Conclusión: el sistema Ultrafil®3D y la técnica de condensación lateral de la gutapercha con conos maestros de conicidad .06 o .02 fueron igualmente eficaces en el sellado apical de conductos curvos. El espaciador penetró en el conducto significativamente más cuando se empleó un cono de conicidad .02.

Palabras clave: *Obturación de conductos radiculares, condensación lateral, gutapercha termoplastificada.*

INTRODUCTION

One aim of root canal treatment is the complete obturation of the root canal system with solid core material and sealer, which requires a tapered preparation to disinfect the root canal system and facilitate its filling (1).
New rotary systems for the preparation of root canals use nickel-titanium instruments of different blade design, size and taper (.02, .04, or .06 mm/mm). With these instruments, more centred and circular canal preparations can be performed compared with the use of stainless steel instruments (2,3). The use of an ISO .06 tapered nickel-titanium rotary instruments prepares a canal that increases 0.06-mm in diameter for every 1-mm of length in an apical-coronal direction (4,5). Canals prepared in this way can be filled by cold lateral condensation of gutta-percha or by various warm gutta-percha obturation techniques (6-10).
Cold lateral condensation of gutta-percha is the most widely used method for root canal obturation, generally using a .02 mm/mm tapered ISO-standardized master gutta-percha cone, and numerous accessory gutta-percha cones (11). Master cones matching the taper of canals prepared with .04 and .06 rotary nickel-titanium instruments have been developed to improve the filling of canals.
Use of a master cone with a larger taper increases the amount of gutta-percha within the canal, reducing the amount of sealant between accessory cones, which is desirable to improve the three-dimensional filling of the canal (12). Use of .06 gutta-percha cone reduces the number of accessory points and the obturation time compared with use of .02 gutta-percha cones with cold lateral condensation (13,14). However, use of a gutta-percha cone matched to the taper of the preparation does not allow spreader penetration to within 1 mm of the working length (15,16) reported that the spreader penetrated significantly closer to working length using of a .02 master cone compared with a .06 tapered master cone, although without compromising the coronal seal. On the other hand, Allison et al. (17) reported that the penetration depth of the spreader with cold lateral condensation affects the quality of the apical seal.
Techniques based on the pre-heating of the gutta-percha were introduced in order to improve the three-dimensional filling of root canals (18). Root canal obturation with injected thermoplasticized gutta-percha was introduced by Yee et al. (7). The injection of low-temperature thermoplasticized gutta-percha can replicate the intricacies of the root canal system (19) and has been compared with lateral condensation using 0.02-mm/mm tapered ISO-standardized master cone in straight root canals prepared with hand instruments (20-23); it achieves a similar seal to that obtained with to other obturation methods. However, Al-Dewani et al. (24) used a dye penetration method and found better sealability with low-temperature thermoplasticized gutta-percha than with lateral condensation in canals prepared with rotary nickel-titanium instruments.
The purpose of this in vitro study was to compare the apical seal in mesio-buccal curved canals prepared with .06-mm/mm tapered nickel-titanium rotary instruments after obturation using Ultrafil® 3D injectable low-temperature thermoplasticized gutta-percha or cold lateral condensation with a .06 or a .02-mm/mm tapered master cone. The second aim was to evaluate the depth of spreader penetration using cold lateral condensation with a .06 or a .02 mm/mm tapered gutta-percha master cone.

MATERIALS AND METHODS

Forty-four mesio-buccal canals in non-restored human molars with fully formed apices were immersed until use in 2% chlorhexidine solution. An X-ray image was obtained from a distance of 2 mm using a Dens-o-mat® 65 kVp-75mA X-ray machine (Philips, Italy) for verification purposes and for determining the curvature of the mesial canals, based on the Schneider technique (25). The curvature of the selected canals was between 25 and 40º in all cases.

Preparation of root canals

Chamber access was achieved with a tapered tungsten carbide bur (number 830 314 010) (Komet, Brasseler, GmbH & Co, Lemgo, Germany) and Zekrya-Endo bur (number E0152) (Dentsply-Maillefer, Ballaigues, Switzerland). The working length was determined by inserting an #0.8 or #10 K-file into the canal until it was just visible at the apical foramen and then subtracting 1 mm. Mechanical instrumentation was performed using a NiTi Endo® contra angle hand-piece (Dentsply Maillefer; Ballaigues, Switzerland) and K3® rotary instruments (SybronEndo, West Collins, CA, USA). A crown-down sequential technique was used to the working length at an apical size 30 and .06 taper. Apical patency was maintained throughout instrumentation by using a #10 K-file (Dentsply-Maillefer, Ballaigues, Switzerland). The operator was trained in instrumentation with the mechanical rotary system. The files were replaced after the instrumentation of six canals. The canals were irrigated between file changes with 2 ml of 2.5% sodium hypochlorite solution. The smear layer was then removed with a final flush of 10 ml of 17% EDTA, followed by 10 ml of 2.5% NaOCl.

Obturation of root canals

After canal instrumentation, all specimens were dried with absorbent .06 tapered paper points (Roeko, GmbH, Langenau, Germany). Root canal sealer AH-Plus® (Dentsply DeTrey, Konstanz, Germany) mixed according manufacturer's instructions was placed with a counterclockwise motion into the root canals using a #20 K-Flexofile® (Dentsply Maillefer, Ballaigues, Switzerland) prior to obturation. The 44 canals were then randomly divided into three groups and prepared as follows:

Group 1 (n=12): Ultrafil® 3D injectable low-temperature thermoplasticized gutta-percha system (Colténe-Whaledent, Konstanz, Germany). The Ultrafil heater was allowed to reach its operating temperature at 90º C. Endoset gutta-percha cannules were placed into the heater for 4 minutes to reach the required heat. The flow of gutta-percha from the cannule was confirmed and the needle was placed into the canal to 6 mm from the apex. After placing the apical increment of gutta-percha, the needle was removed from the canal and the cannule was again placed in the heater. The apical increment of gutta-percha was apically condensed with a prefitted hand plugger (Machtou Dentsply Maillefer). The process was repeated in the middle and coronal third using larger pluggers until the canal obturation was completed. Vertical pressure was maintained as the gutta-percha cooled to minimize shrinkage.

Group 2 (n=12): Cold lateral condensation with .06-mm/mm tapered ISO-standardized master cone (Roeko, GmbH, Langenau, Germany). After placing AH-Plus® in the canal, a size 30 .06 gutta-percha cone was trimmed as necessary to give tugback at working length, and the master cone was then coated with sealer and placed into the canal at working length. Medium-fine accessory gutta-percha cones (Dentsply Maillefer, Ballaigues, Switzerland) were then added to all roots until a NiTi D11T endodontic spreader (Dentsply Maillefer, Ballaigues, Switzerland) no longer penetrated the coronal third of the canal. After the lateral condensation, the gutta-percha cones were sectioned at canal orifice level using a heated instrument (GP heater, Maillefer, Ballaigues, Switzerland). Then the gutta-percha mass was condensed vertically using a nº. 4 Machtou plugger (Dentsply Maillefer) for 30 s.

Group 3 (n=12): Cold lateral condensation with .02-mm/mm tapered ISO-standardized master cone (Dentsply-Maillefer, Ballaigues, Switzerland), following the same steps described above for group 2.

In Groups 2 and 3, the penetration depth of the spreader was measured in each canal and subtracted from the working length.

Positive controls (n=4): The root canals were prepared but were not root-filled in order to demonstrate microleakage along the entire length of the canal.

Negative controls (n=4): The root canals were prepared, filled and completely covered with two layers of nail polish varnish.

Apical dye penetration

After the filling, the canals were stored in 100% humidity at 37ºC for 72 hours to allow the sealer to set. Then, the canals were dried and coated with three layers of nail polish covering the whole tooth, including the access restoration but not the apical 2 mm of the root. The specimens were then immersed in India ink for seven days at 37ºC. After this time, the roots were washed in water and the nail polish and India ink were carefully removed with surgery blade.

Canals were then embedded in Inplex® (Tecmicro, Parma, Italy) cold-polymerizing transparent acrylic resin. Transversal sections of 700 µm thickness were made with an Accutom 50 (Struers A/S, DK-2610, Copenhagen, Denmark) hard tissue microtome and a disc of 200 µm thickness, sectioning from the apex and ascending apico-coronally. Five transversal section were made and evaluated in millimetres of apical dye penetration.

The resulting sections were examined independently by two observers at 20x magnification with a Nikon SZ4045TR surface stereoscopic microscope (Olympus Optical Co., Hamburg, Germany) to determine the presence or absence of dye.

Statistical analysis

The Student´s t test was used to evaluate whether there were significant differences in spreader penetration depth. Because the results for each group did not follow a normal distribution, the variables were analysed using a non-parametric test. Global comparisons were made by using the Kruskal-Wallis test and the Mann-Whitney test for paired comparisons. A p-value of 0.05 was regarded as significant.

RESULTS

The positive controls demonstrated microleakage after one day, whereas the negative controls did not leak for the entire observation period, thereby validating the testing model.

Table 1 shows the distribution of the scores and mean values of the microleakage in each study group, as well as the results of paired and global comparisons. The global comparison showed no significant differences in mean microleakage among the three groups (p=0.396), which showed very similar values: 0.42 ± 0.669 for the Ultrafil® 3D thermoplasticized gutta-percha system, 0.75 ± 0.754 for cold lateral condensation with .06-mm/mm tapered ISO-

standardized master cone and 0.42 ± 0.515 for cold lateral condensation with .02-mm/mm tapered ISO-standardized master cone. No significant differences were found in paired comparisons.
When a .02 tapered master cone was used, the spreader penetrated significantly closer to working length (1.87±0.27) than when a .06 tapered master cone was used (3.21±0.39) ($p<0.001$).

Table 1. Microleakage scores for the three study groups (in millimetres).

	Microleakage			
Obturation technique (n=12)	**0**	**1**	**2**	**($\bar{x}$ ± s)**
Ultrafil®3D system	8 (66.7)	3 (25.0)	1 (8.3)	0.42 ± 0.669
Cold lateral condensation (.06-mm/mm cone)	5 (41.7)	5 (41.7)	2 (16.7)	0.75 ± 0.754
Cold lateral condensation (.02-mm/mm cone)	7 (58.3)	5 (41.7)	0	0.42 ± 0.515
Comparison (*p*)	0.396			

$\bar{x}$: arithmetic mean. s: standard deviation. n: sample size.
0: no dye penetration. 1: one millimetres of dye penetration. 2: two millimetres of dye penetration.
Values joined by the vertical line were not significantly different.

DISCUSSION

The preparation of curved root canals has improved thanks to the introduction of new nickel-titanium instruments (3). The present study used mesio-buccal canals of human molars with a curvature of 25–40º in all cases, which were prepared with .06 tapered rotary nickel-titanium instruments. K3® file instruments can prepare a good shape in curved canals with minimal canal transportation (26, 27) and few changes in the cross-sectional area of the root canal (28).
Cold lateral condensation of gutta-percha is the most widely used method for root canal obturation (11), but techniques based on the pre-heating of the gutta-percha were introduced in order to improve the three-dimensional filling of curved and straight root canals (18). This study compared the lateral condensation of cold gutta-percha using two different master cones (taper .06 or .02) with a low-temperature thermoplasticized gutta-percha technique (Ultrafil® 3D) in the filling of root canals prepared with.06 taper rotary nickel-titanium instruments.
Varied results have been published by studies comparing the use of warm gutta-percha and cold lateral condensation techniques in the three-dimensional filling of root canals prepared with hand instrumentation. De Moor & De Boever (29) achieved a better apical sealing with cold lateral condensation and a hybrid gutta-percha condensation technique than with techniques using thermoplasticized gutta-percha. However, Wu et al. (12) found no significant differences between the cold lateral condensation method and vertical compaction of warm gutta-percha and Vizgirda et al. (30) found no significant differences between the cold lateral condensation method and the high-temperature thermoplasticized gutta-percha technique.
Most authors (20-23) have reported that the injection of low-temperature thermoplasticized gutta-percha achieves a similar level of canal sealing to that obtained with cold lateral condensation. The results of the present study are similar, since no significant differences in the means of apical leakage were found between the cold lateral condensation method and the low-temperature thermoplasticized gutta-percha technique. However, Al-Dewani et al. (24) observed lower apical leakage in straight and curved root canals filled with the Ultrafil® system compared with the cold lateral condensation method.
Hembrough et al. (13) studied the efficacy of the lateral condensation of gutta-percha in single-rooted teeth using three tapered master cones: an ISO-standardized gutta-percha cone, a Dia-ISOGT.06 gutta-percha cone and a size medium gutta-percha cone, and found no significant differences in the quality of the obturation. Gordon et al. (14) compared the area filled by gutta-percha, sealer and voids in standardized simulated curved canals and in mesio-buccal canals of extracted maxillary first molars filled with a .06 taper single cone technique or with lateral condensation of multiple .02 gutta-percha points. They found no differences between the techniques in the amount of gutta-percha occupying a prepared .06 tapered canal.
Bal et al. (16) showed that canal obturation with .06 or .02 tapered gutta-percha master cones was equally efficacious to prevent coronal microleakage in these canals, despite statistically significant differences in the penetration depth of the spreader. In the present study no significant differences in apical leakage were observed among the study groups. However, the mean leakage was less in canals filled with .02 tapered master cone than in those filled with tapered .06 master cone, attributable to the greater penetration depth of the spreader in the group filled with an .02 tapered master cone. In this context, Allison et al. (12) found that teeth in which a spreader tip could be inserted within 1 mm of the working length with the master cone in place had considerable less apical leakage in comparison to teeth with a greater distance between the spreader tip and working length.

CONCLUSION

Under the conditions of this study, cold lateral condensation using a .06-mm/mm or .02-mm/mm tapered ISO-standardized master cone and filling using the Ultrafil® 3D injectable low-temperature thermoplasticized gutta-percha system proved equally efficacious in the apical sealing of curved canals prepared with .06-mm/mm tapered nickel-titanium rotary instruments. The depth of spreader penetration was higher using .02 tapered gutta-percha master cone.

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