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A Comparison between a New Vacuum Obturation Technique and Lateral Condensation: An In Vitro Study

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A new machine that allows cleaning root canals without conventional instruments has been introduced. Because this noninstrumented technique does not enlarge the root canal system, a new device had to be developed to fill the root canal system. The new machine was able to produce a vacuum that allowed proper drying and filling of a root canal system. This study evaluated the new vacuum filling method and compared it with lateral condensation.

Canals of 40 extracted human molars, instrumented using the step-back technique, were either filled with the new vacuum obturation technique using AH26 sealer and a gutta-percha single cone or by lateral condensation. Teeth were coated with wax and placed into India ink for 7 days. The wax was then removed and the teeth were cleared. All teeth were evaluated for linear dye penetration using a ×20 viewer.

Obturation with the new vacuum technique resulted in significantly less leakage than lateral condensation.

Lussi et al. (1) introduced a new machine that allowed cleaning root canals without conventional instruments. The conclusion of their in vitro study was that it is possible to clean a root canal system by a noninstrumented technique at least as well as by conventional hand instrumentation.

Proper filling of the root canal system is considered essential for successful root canal therapy. The filling should be a bacteria-tight seal (2).

Weine (3) stated the importance of the concept that canals must be filled to retain the periapical tissues at their most desirable condition; healing is initiated once the canals are properly prepared. However, unless the canal space is closed by filling, the irritants, metabolites, and microorganisms that may cause periapical breakdown have the opportunity to return. This may lead to recurrence of the lesion.

The abovementioned new noninstrumented cleaning technique does not enlarge the root canal system in a standardized manner nor are irregularities of the walls removed. The obturation procedure has to take this into consideration. To successfully fill such fine, irregular-shaped canals, a new vacuum obturation technique was developed. Therefore, the aim of this study was to compare this new vacuum filling method with the conventional lateral condensation technique.

MATERIALS AND METHODS

Access preparations were performed on 44 extracted human molars using a standardized conical drill, 3-mm in diameter (Meditec SA, Ecublens, Switzerland).

All root canals were prepared by one operator (P. P.). All teeth were instrumented with K-Flexofiles (Maillefer SA, Ballaigues, Switzerland) to a master apical file (MAF) #35. The working length was determined by placing a #15 file into the canal until the tip of the file was just visible at the apical foramen and then it was drawn back 1.0 mm. Copious irrigation with 3% sodium hypochlorite was used throughout the instrumentation procedure. Step-back flaring of the canal at 1, 2, 3, 4, and 5 mm short of the established working length was accomplished by instrumenting in a sequential manner to five files larger than the MAF.

The canal curvature was then estimated by visual inspection from the apical foramen to the coronal access preparation. Scoring of the canal curvature was as follows (4): deviations 0 to 5 degrees: score 0, straight canal; deviations 5 to 30 degrees: score 1, slightly curved canal; and deviations >30 degrees: score 2, curved canal.

The teeth were paired according to the degree of curvature and number of roots and randomly divided into two experimental groups of 20 teeth each.

Four teeth were instrumented but not obturated and served as technique controls. To serve as negative controls, two teeth were completely coated with sticky wax to evaluate the sealing effect of sticky wax. To serve as positive controls, two teeth were completely covered with sticky wax except for the apical 2 mm. The positive control teeth were used to verify the ability of the India ink to penetrate through the instrumented apical foramen.

After completion of the preparation, the canal was irrigated with absolute ethyl alcohol and dried with paper points. Patency of the apical foramen was maintained by passing the #15 file 1 mm past the apical foramen.

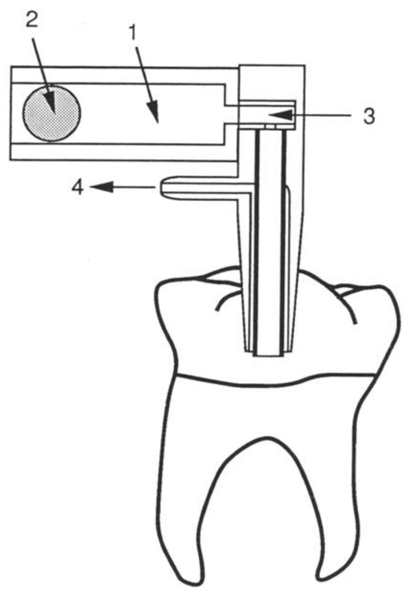

FIG 1. A connecting piece was tightly fitted in the access cavity of the tooth. The connecting piece consists of *1*) a reservoir for filling paste, *2*) a steel ball placed on top of the filling paste, *3*) an integrated faucet and *4*) a pipe to vacuum pump.

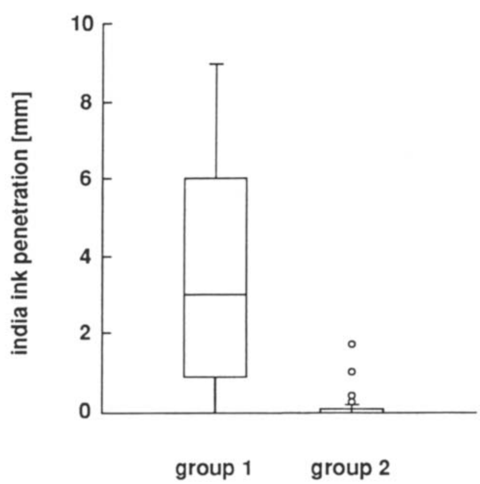

FIG 2. Box plot of linear measurements lateral condensation (group 1, $n = 19$ root canals), new vacuum technique (group 2, $n = 25$ root canals). O, outside values.

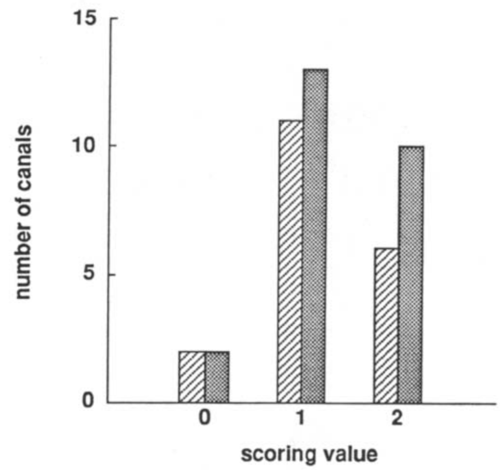

FIG 3. Distribution of canal curvature in the two groups.

FIG 4. Root obturated with lateral condensation, showing 0.7-mm linear leakage (original magnification ×2.5).

For all canals in both groups, a standardized master gutta-percha cone (Maillefer SA) fitted with the length of the MAF was selected. In order to achieve a vacuum, a piece of Parafilm ("M" Laboratory Film; American National Can, Greenwich, CT) was adapted over the apex. The Parafilm was then fixed with a rapidly setting zinc phosphate cement (Ultraphos Woelm, Bielefeld, Germany) that could be easily removed after obturation without damaging the apex area of the tooth.

The obturation procedure for the lateral condensation group (group 1) was as follows: AH26 (De Trey (Dentsply, Konstanz, Germany) was mixed according to the manufacturer's instructions (1 g of resin, 1.6 g of powder). It was placed onto the canal walls with a slowly rotating Lentulo #1 (Maillefer SA). The apical part of the master gutta-percha cone also was coated with sealer and it was then inserted into the canal to the working length. A finger spreader size B (Maillefer SA) was set in the canal as low as possible but not nearer than 1 mm to the working length. Accessory cones (#25; Maillefer SA) coated with sealer were laterally condensed. Excess material was removed with a heated hand excavator.

The teeth of the vacuum obturation group (group 2) were treated in the following way: AH26 (mixed 1:1) was evacuated for 5 min with the same vacuum pump that was later used for filling. A connection piece (Fig. 1) tightly fitted in the conical access cavity was joined to the vacuum device by a plastic tube. The cylindrical reservoir of the connection piece was filled with AH26. To avoid air aspiration, a metal ball

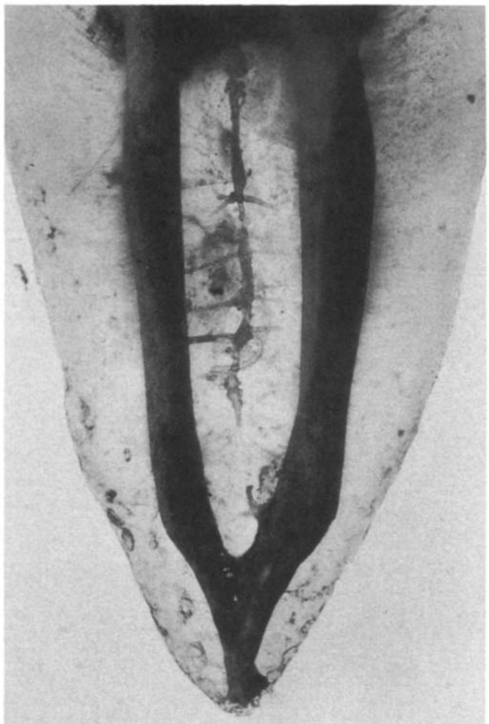

FIG 5. Root obturated with the new vacuum obturation technique, showing no leakage (original magnification ×2.5).

was placed on top of the filling material. Then the vacuum pump was operated to create a vacuum inside the dental cavity. The root canals were also dried of any residual irrigant by this vacuum, without the use of absorbent paper points. When the vacuum in the dental cavity had been stable at 15 hPa for at least 1 min, the faucet was opened and the filling material was sucked into the cavity. The vacuum pump was stopped when the filling material reached the plastic pipe leading to the vacuum pump. The apical part of the master gutta-percha cone was coated with sealer and then inserted into the canal to the working length.

The teeth were placed into coded vials at 37°C and 100% humidity for 7 days to allow the sealer to completely set.

When the obturation was complete and the sealer had set, cotton pellets were placed in all pulp chambers. All teeth were coated with boxing wax (Kerr, Emeryville, CA) except for the apical 2 mm. All experimental and control teeth were placed in India ink (Pelikan Black Drawink, pH 8.07; Pelikan AG, Hannover, Germany) for 7 days. The roots were rinsed with tap water and the wax was completely removed with a hand scaler.

The teeth were then decalcified by being placed in 5% nitric acid (2 days, daily change of nitric acid), dehydrated with 75% ethyl alcohol (1 day) and absolute ethyl alcohol (1 day), and then cleared in methyl salicylate.

Linear dye leakage was evaluated using an Olympus Zoom Stereo Microscope SZ-Tr ×20 illuminated viewer (Olympus Optical AG, Volketswil, Switzerland). One ocular was equipped with an integrated scale (Messokular G10XSP, Olympus Optical AG). Each cleared root was rotated to best visualize the greatest extent of leakage, which was measured to the nearest 0.1 mm. Measurements were made beginning from the apical constriction to the most coronal extent of leakage.

Repeated measurement of 10 randomly selected teeth (5 of each group) was done after 6 wk.

The repeated measurements were evaluated for rater reliability using Pearson correlation coefficients and then the mean leakage was analyzed by the Mann-Whitney U test to check for statistically different dye penetration between the groups. Postinstrumentation curvature between the groups was checked with a Pearson chi-square test and correlated with leakage for each specimen in both groups using Kruskal-Wallis analysis of variance.

RESULTS

Most of the teeth were cleared completely. Ten big teeth had opaque regions that did interfere with dye measurement and were therefore excluded from the study. Finally, 19 root canals in group 1 and 25 in group 2 could be evaluated.

The positive controls showed dye leakage throughout the length of the canals, while the negative controls had no dye penetration.

The Pearson correlation coefficient for repeated measurements of the rater was $r = 0.958$ ($p < 0.001$) showing a high reproducibility of dye penetration measurements.

Box plots of linear leakage values are shown in Figure 2. There was a significant difference in the average amount of leakage between the two groups as determined by the Mann-Whitney U test ($p < 0.001$). The lateral condensation group leaked more (3.44 mm ± 2.85) than the vacuum obturation group (0.19 mm ± 0.42). Leakage was between 0.0 and 9.0 mm for the lateral condensation group and between 0.0 and 1.7 mm for the vacuum obturation group.

Measurements more than two standard deviations away from the mean were classified as complete outsiders and were excluded from further statistical analysis.

Distribution of canal curvature for both groups is shown in Fig. 3. A Pearson chi-square test showed no significant difference ($p = 0.84$) in canal curvature between the two groups.

Curvature was then correlated to average leakage for each root. There was no significant correlation between curvature of the root and linear leakage in both groups as determined by Kruskal-Wallis analysis of variance (group 1, $p = 0.55$; group 2, $p = 0.49$).

Average obturation time for one root canal in the lateral condensation group was 6.5 min. The mean time to fill a tooth with the vacuum technique was 16.3 s (excluding the preparation of the reservoir and placing of a gutta-percha cone).

Figures 4 and 5 show representative examples from each group.

DISCUSSION

The new noninstrumented vacuum filling technique resulted in 0.19-mm India ink penetration and a better apical seal than the lateral condensation group (3.4-mm penetration).

Overall, similar results were obtained by Messerli (5) with an older vacuum filling technique when compared with lateral condensation. Root canals not enlarged by noninstrumented cleaning, however, resulted in slightly better values apically using the vacuum technique.

We combined the vacuum filling technique with a single gutta-percha cone the size of the MAF. This technique results in better apical dye penetration values than conventional combination of sealer and a single gutta-percha cone as evaluated by Beatty et al. (6). They found 6.31-mm apical dye penetration.

In summary, the penetration values for lateral condensation in this study are within the range of earlier studies. Dye penetration values ranged from 0.3 to 4.16 mm (6–11).

Comparison to the above-mentioned different studies is difficult, because the penetration length is dependent on the study design, e.g. resection of the crown of the teeth, mode of lateral condensation, access preparation, penetration time and physical properties of the dye, and the penetration evaluation method.

In this study the crowns of the teeth were not resected from their roots and access preparation (3-mm in diameter) was the same for both experimental groups. This probably explains the rather high leakage of the lateral condensation group due to more difficult access while filling the roots.

As Fig. 3 shows, the number of canals with a specific root curvature are equally distributed between groups 1 and 2 as tested by the Pearson chi-square test ($p = 0.84$). Analysis of variance showed no different leakage for the different root curvatures. Messerli (5) also found similar sealing for all groups of root curvature in the lateral condensation and the vacuum obturation group.

As preliminary experiments showed, mixing AH26 in a ratio 1:1 to reduce viscosity, results in better values using the vacuum filling technique. To verify the set, a sample of sealer was stored under the same conditions as the teeth; 100% humidity and 37°C. No difference in the set of the AH26 was noted.

To evaluate dye penetration in the microscope the samples were coded; however, blind observations were not possible due to visible presence of the condensed gutta percha in the lateral condensation group.

The new obturation procedure is less time-consuming than lateral condensation. If a good vacuum is established, obturation is a matter of seconds. Obturation of teeth with several roots does not take more time than obturation of a single-rooted tooth. Clinically, building-up a deeply destroyed tooth such that a sufficient vacuum can be achieved, may be the most time-consuming step. Once a tooth is rebuilt, cleansing and obturation with the new noninstrumented technique may then be faster than any known technique, which would be of great advantage in daily practice. In summary, cleaning the roots of a tooth would take between 10 and 15 min (5), filling the tooth only a few seconds, as shown in this study.

Alfter (12) filled root canals in vivo with a similar vacuum system. The teeth were conventionally instrumented. Radiographs often showed incomplete filling, especially when teeth were overinstrumented apically. As the root canal system is not enlarged with the new noninstrumented cleansing technique (1), filling with the new vacuum system should be more successful in vivo.

Further research has to be undertaken to show if this device is capable of filling root canals in vivo. Other variables have also to be taken into account, e.g. aspiration of liquid from the periapical tissue.

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