Original Article

In Vitro Evaluation of Apical Sealing Ability of HEROfill® Obturator versus Cold Lateral Condensation in Curved Root Canals

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Abstract
Objectives: This study aimed to assess and compare the apical sealing ability of HEROfill® Soft-Core system and lateral condensation technique in fine curved canals using the fluid filtration method.
Materials and Methods: Forty human mesiobuccal root canals of mandibular first molars with 25° to 40° curvatures were instrumented to an apical size 30/0.04. Roots were randomly assigned to two experimental groups of 15, designated as groups A and B. Two control groups, each containing five teeth, served as positive and negative controls. Group A was obturated using lateral condensation technique and group B with the HEROfill® Soft-Core system. The groups were tested for microleakage using an in vitro fluid filtration apparatus with 0.5 atm pressure at zero, two, four, six, eight and 10 minutes. Independent t-test was used to analyze the microleakage data.
Results: The mean and standard deviation (SD) values for fluid microleakage in the lateral condensation group were 0.58±0.49 µL/min, 0.68±0.35 µL/min, 0.74±0.22 µL/min, 0.71±0.29 µL/min and 0.60± 0.29 µL/min at two, four, six, eight and 10 minutes, respectively. The mean and SD values for fluid microleakage in the HEROfill® group were 0.53±0.42 µL/min, 0.67±0.34 µL/min, 0.69±0.26 µL/min, 0.73±0.33 µL/min and 0.63±0.26 µL/min at two, four, six, eight and 10 minutes, respectively. The difference between the lateral condensation and HEROfill® groups was not statistically significant at two (P=0.776), four (P=0.909), six (P=0.562), eight (P=0.861) or 10 (P=0.765) minutes.
Conclusion: The HEROfill® system and cold lateral condensation technique were equally effective for apical sealing of curved canals.
Keywords: Dental Leakage; Root Canal Filling Materials; Root Canal Therapy; Root Canal Obturation

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INTRODUCTION

The main goal of endodontic therapy is to completely disinfect the root canal system, totally fill the root canal space and seal the root canal three dimensionally without any fluid leakage through the apical foramen [1-3]. Complete obturation of the root canal space may increase the clinical success rate to almost 96% [4]. Inadequate or incomplete root canal obturation is the cause of nearly 60% of endodontic failures [4,5]. Leakage of microorganisms and their by-products through the interface of dentinal walls and filling material may reinfect the canal [4,6]. Complete debridement and obturation of the root canal system may be easy in straight canals, but achieving these goals in severely curved canals can be difficult [7,8]. Obtaining a proper seal in the root canal system is critical in endodontic treatment [9].

Although numerous techniques using gutta-percha have been developed to achieve an adequate three-dimensional obturation, cold lateral condensation in combination with a root canal sealer is still one of the most popular techniques [10,11]. This technique can be effective in most teeth, but might be difficult or even impossible in severely curved canals. If fine spreaders fail to reach the apical one-millimeter of the canal or the taper of the prepared canal is less than that of the spreader, lateral condensation may not be the method of choice for root canal filling [12]. In such cases, warm or thermo-plasticized gutta-percha techniques have been suggested [12]. Da Silva et al. used digital radiography for detecting voids in curved canals obturated with Thermafil™ obturator versus lateral condensation method. No voids were found in Thermafil™ group whereas small voids were detected in most canals filled with lateral condensation technique. In addition, they reported thicker layer of sealer in the middle and apical parts of the canals obturated with Thermafil ™ [13]. Another study demonstrated that the thickness of sealer layer negatively influenced the sealing ability of the root canal filling [14].

HEROfill® Soft-Core system (Micro-Mega, Besançon, France) is a third generation endodontic obturator consisting of a solid plastic carrier coated with thermoplastic α-phase gutta-percha. The HEROfill® system is comparable to Thermafil™ (Dentsply Maillefer, Ballaigues, Switzerland); they are both carrier obturation systems and use thermo-plasticized gutta-percha as a coating [15,16].

The aim of this study was to compare the apical microleakage of curved root canals filled with HEROfill® and cold lateral condensation techniques using the fluid filtration method.

MATERIALS AND METHODS

A total of 40 extracted human mandibular first molars with 25° to 40° canal curvatures and two separate canals were collected. These teeth had mature apices and no caries, cracks or resorption on the root surface. The degree of canal curvature was determined using the method described by Pruett et al, [17] with a computerized digital image processing system (AutoCAD 2007; Autodesk Inc., San Rafael, CA, USA).

Debris and calculus on the root surfaces were removed using a curette. After coronal access cavity preparation, apical patency of the root canal was checked using a #10 K-file (Maillefer, Ballaigues, Switzerland). The crowns of the teeth were cut perpendicular to the long axis of the root to obtain a mesiobuccal root canal measuring 16 mm in length. The working length of each canal was determined visually by subtracting one-millimeter from the length of a #10 K-file at the apical foramen.

Root canal shaping was performed with HERO Shaper rotary instruments (Micro-Mega, Besançon, France) according to the manufacturer's instructions. After initial canal enlargement using a #15 K-file, the coronal two-thirds of the root canal were instrumented with 20/0.06 file, and 20/0.04, 25/0.04 and 30/0.04 files were then used to prepare the canal to the working length. After each instrument, the root canals were irrigated with 5 mL of 2.5% sodium hypochlorite (NaOCl) using a 27-gauge needle and lubricated with RC Prep (Premier Dental Products Co., Philadelphia, PA, USA). All canals were prepared using a crown-down technique at a speed of 450 rpm and a 16:1 reduction hand piece (W&H 975; Dental Work, Burmoos, Austria) and torque-controlled electric motor (TC Motor 3000, Nouvag, Goldach, Switzerland). The smear layer was removed by a rinse with 3 mL of 17% ethylenediaminetetraacetic acid (EDTA) for 30 seconds followed by a final rinse with 3 mL of 5.25% NaOCl. Root canals were dried with paper points before filling.

The roots were then divided randomly into two experimental groups of 15 teeth each and two control groups of five teeth each (positive and negative control groups) and obturated as follows:

In group A, canals were filled with #30 HEROfill® obturator, which was the same size as the last file used to working length. A thin layer of AH26 sealer (DeTrey, Dentsply, Konstanz, Germany) was manually placed in the coronal portion of the canal with a size 30 verifier. HEROfill® obturator was heated in the HEROfill® oven for 60 seconds and then introduced to the working length. Final radiographs were taken to ensure the quality of the obturation. The handle of the obturators and excess gutta-percha were removed after cooling using an inverted cone bur and a high-speed handpiece.

In group B, canals were obturated using the cold lateral condensation technique. For each canal, a master cone size 30/02 coated with sealer was placed into the canal to the working length. A finger spreader size B (Maillefer, Ballaigues, Switzerland), one-millimeter short of the working length, was selected and #20 accessory gutta-percha cones coated with sealer were used until an accessory cone could not be introduced for more than 3 mm into the canal. Excess gutta-percha was removed from the canal orifice and the coronal gutta-percha was vertically condensed with a finger plugger size 4 (Dentsply Maillefer, Ballaigues, Switzerland).

In group C (positive control), canals were filled using HEROfill® core material without the use of a sealer.

In group D (negative control), canals were left unfilled and coated with two layers of nail varnish.

Following obturation, the teeth were stored at 37°C in 100% humidity for 72 hours to ensure complete setting of the sealer. After incubation, root surfaces except for the apical 2 mm were coated with two layers of nail varnish and sealed with two layers of Parafilm strips (laboratory film; Chicago, IL, USA). The apical end of the root except for the apical foramen was covered using cyanoacrylate glue and inserted into a plastic tube (0.5 cm internal diameter and 5 cm long). The free end of the tube was then connected to a fluid filtration apparatus as described by Javidi et al, [18] for endodontic studies. The fluid filtration test was conducted under 0.5 atm pressure. An air bubble was introduced into the system using an air syringe.

Microleakage was quantitated by the movement of a small air bubble in the micropipette. First observation was done after 30 seconds for localization of the bubble for each sample by a digital camera (C 765, Olympus, Tokyo, Japan). Other measurements were made at two-minute intervals for 10 minutes (two, four, six, eight and 10 minutes after the first picture). Leakage quantity was expressed as µL/min/cm H_2O and the mean values were calculated.

The differences in fluid transport between the groups were statistically analyzed with independent t-test and statistical significance was set at $P< 0.05$.

RESULTS

The positive controls showed excessive fluid transport, while the negative controls registered no detectable bubble movement at 0.5 atm pressure. The mean microleakage values in the experimental groups are presented in Figure 1.

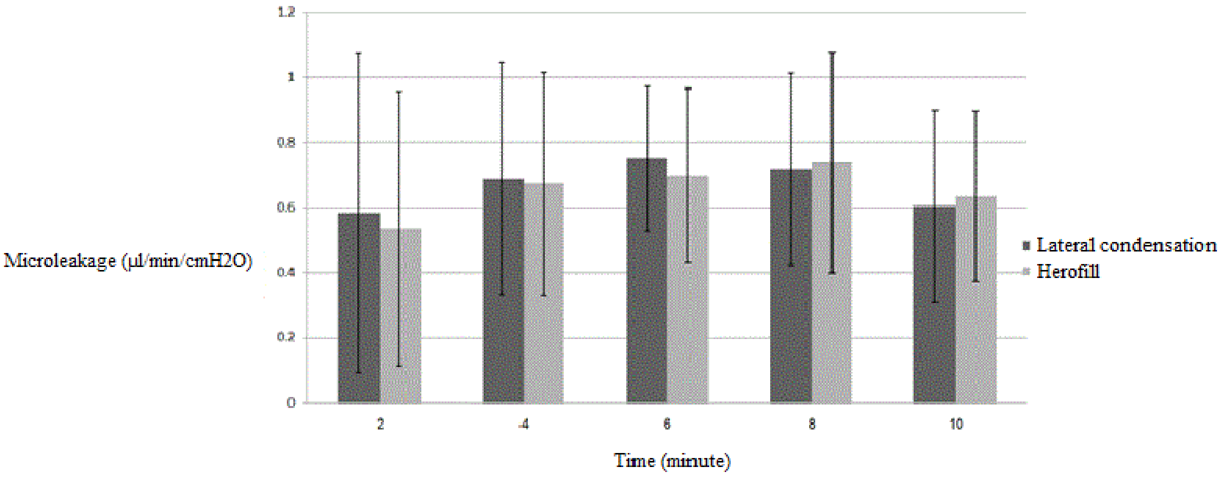

Fig. 1. Microleakage in the experimental groups

The mean± standard deviation (SD) fluid microleakage for the lateral condensation group at minutes 2, 4, 6, 8, and 10 was 0.58±0.49 µL/min, 0.68±0.35 µL/min, 0.74±0.22 µL/min, 0.71±0.29 µL/min and 0.60±0.29 µL/min, respectively. The mean±SD fluid microleakage for the Herofill® group at minutes 2, 4, 6, 8, and 10 was 0.53±0.42 µL/min, 0.67±0.34 µL/min, 0.69±0.26 µL/min, 0.73±0.33 µL/min and 0.63±0.26 µL/min, respectively. Analysis of the data showed no significant difference between HEROfill® and lateral condensation techniques at two (P=0.776), four (P=0.909), six (P=0.562), eight (P=0.861) and 10 (P=0.765) minutes.

DISCUSSION

The purpose of this study was to assess the sealing ability of HEROfill® and lateral condensation techniques in the curved canals of the mesial roots of mandibular first molars.
The results indicated that there was no statistically significant difference in the sealing ability of these obturation methods using the fluid filtration system.
Microleakage studies are well accepted to measure the sealing ability of root canal fillings [2].
Several methods have been recommended to evaluate apical leakage such as linear dye leakage, electrochemical method, radioisotope labeling, bacterial leakage and fluid filtration [19,20].
Since a fluid-tight seal at the apical foramen is essential for the success of endodontic treatment, the fluid filtration method is one of the best techniques for evaluation of apical microleakage [21,22].
The main advantage of the fluid filtration method is that the specimens are not destroyed and can be re-measured, allowing analysis at different time points. Moreover, this technique has proven to be reliable and reproducible [19].
Other advantages of this technique include enabling quantitative measurements and providing accurate results because very small amounts can be recorded, the exact time that the maximum leakage occurs can be determined and the samples are not affected by the test procedures [3,15,23].

No tracer is needed in this technique; thus, the associated problems with regard to molecular size, affinity for dentin or pH are eliminated. Unlike bacterial penetration or radioactive studies, this method does not require any intricate materials [24]. Thus, the fluid filtration method was used in our study. In the current study, we standardized the samples in terms of root length and diameter of apical foramina to ensure the uniformity of the roots. Sodium hypochlorite and EDTA were used as irrigants for smear layer removal. The absence of smear layer improves the seal at the sealer-dentin interface as Cobankara et al. proved that AH26 root canal sealer provided a better seal when the smear layer was removed [25]. AH26 sealer has desirable properties such as low microleakage. Kardon et al. [19] noted higher microleakage when AH Plus root canal sealer was used rather than AH26. Therefore, AH26 was used as root canal sealer in the current study.

Successful endodontic treatment depends on complete obturation and sealing of the root canal system. A variety of root canal obturation systems have been developed to improve the seal of the prepared root canal. However, none of these methods can provide a leak-proof seal [10]. Complete obturation and sealing of curved canals might be more difficult than straight canals [12]. Although cold lateral condensation of gutta-percha is the most widely used technique for root canal filling, warm or thermo-plasticized gutta-percha techniques may provide a better quality of obturation in curved canals [12]. Thermoplastic carrier-based systems offer numerous potential advantages. Among them, HEROfill® is a fast, reliable and simple obturation method. This study compared the apical sealing of HEROfill® system, a third generation endodontic obturator, with that of lateral condensation of cold gutta-percha in curved canals.

Since cold lateral condensation is the most commonly used and studied technique for canal obturation, it serves as a standard with which other techniques can be compared [11]. In the current study, the gutta-percha coated carrier technique, HEROfill® Soft-Core system, showed similar level of apical sealing to that obtained by cold lateral condensation.

This result is in agreement with the findings of Abarca et al [26]. They selected curved canals of the mesial roots of human mandibular molars. The canals were obturated using the Thermafil™ technique, another gutta-percha coated carrier method, and the lateral condensation technique. The HEROfill® Soft-Core system appears to be comparable with the Thermafil™ system because both involve a central carrier covered with α-phase gutta-percha, the use of a verifier and a gutta-percha heating oven. They found no significant differences between the apical sealing obtained using cold lateral condensation method and Thermafil™ technique. In another study, Schäfer and Olthoff [11] compared Thermafil™ obturators with cold lateral condensation method. They found that as long as a sealer was used, the curved canals obturated with Thermafil™ were equivalent in terms of dye penetration to those filled with lateral compaction technique. Similarly, in another study Lares and ElDeeb [27] used curved canals of the mesial roots of mandibular molars and obturated them with Thermafil™ obturation technique or lateral condensation. Using linear dye leakage method, they found no statistically significant difference between the two methods in curved canals.

However, In contrast to our current findings, Zarei et al. [28] used cone beam computed tomography to compare the quality of HEROfill® obturation with lateral condensation method. They also studied the effect of curvature on adaptation of filling materials to dentinal walls of root canals.

The results of their study showed larger gap area between filling materials and dentinal walls in the lateral condensation group. The least gap was found in the HEROfill® group with curves < 25˚.

In another study, Leung and Gulabivala [29] compared the apical leakage of lateral condensation and Thermafil™ methods in root canals with curvatures either greater or less than 25°. Using dye penetration technique, they concluded that the microleakage in lateral condensation group was more than in Thermafil™ in canals with curvatures greater than 25˚. However, there were no significant differences between the techniques in the relatively straight canals. Boussetta et al. [16] achieved a better apical seal with HEROfill® Soft-Core system than with cold lateral condensation technique. However, De Moor and Martens [30] compared the microleakage of three obturation systems and concluded that HEROfill® had the highest leakage compared to thermomechanical and lateral condensation techniques.

The discrepancies between our results and those of other studies may be attributed to the different microleakage evaluation techniques used. Method of leakage assessment used by De Moor and Martens was linear dye penetration after transverse sectioning of the teeth [30].

The fluid filtration method has been more acceptable for measuring leakage than linear dye penetration measurement technique. Dye penetration studies have several limitations: the trapped air restricts the penetration of dye [31], the molecular size of most dye particles is smaller than that of bacteria and the degree of leakage is measured in one plane, making it impossible to evaluate the total apical leakage [3,32]. Another reason that may account for these inconsistent results may be the tooth selection; molar teeth with curved canals were selected for our study, but straight single-rooted teeth were used by Boussetta et al, [16] and De Moor and Martens [30].

According to our experience, HEROfill® obturation method is less time-consuming and easier than lateral condensation. Although not measured separately for each sample, the time required for placement of the filling material using HEROfill® system was less than with lateral condensation.

CONCLUSION

Under the conditions of this study, it was demonstrated that both cold lateral condensation and HEROfill® root canal obturation techniques were equally efficient for the apical sealing of curved canals and both methods exhibited apical microleakage in vitro.

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