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Comparison of apical and coronal sealing in canals having tapered cones prepared with a rotary NiTi system and stainless steel instruments

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Abstract: The purpose of this study was to compare the sealing ability of different tapered gutta percha cones that were used with lateral compaction and single cones in canals prepared with various root canal instruments. One hundred extracted maxillary incisor roots were used. In group 1, 30 roots were prepared with stainless steel instruments (SS) and then filled by the lateral compaction technique using .02 tapered master cones. In group 2, 30 roots were prepared with ProFile® nickel titanium instruments (NiTi) and filled in the same way as group 1. In group 3, 30 roots were filled by the single cone technique using 0.06 tapered gutta-percha cones. The remaining 10 teeth were taken as two control groups. Apical and coronal leakage was evaluated using the fluid filtration model. Considering the effects of the instrumentation, no statistically significant differences were found between the groups prepared with SS and NiTi (*P* > 0.05). When the effects of obturation technique were taken into consideration, the ProFile® instruments and lateral compaction resulted in significantly less coronal leakage than the SS instruments and lateral compaction (*P* < 0.05). There were no significant differences in apical leakage among any of the groups (*P* > 0.05). (J Oral Sci 51, 103-107, 2009)

Keywords: profile instruments tapered gutta-percha; apical and coronal sealing.

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Introduction

The main purpose of root canal treatment is to prepare the root canal system according to its anatomic features, clean it, and then obturate it three-dimensionally in order to provide the maximum level of sealing ability.

This can be achieved through biomechanical preparation that aids obturation and also eliminates any microorganisms in the system. The motor-driven nickel titanium instruments in current use were developed to serve this purpose. In addition to having extreme flexibility due to their materials, their usage with motors provides fast, efficient and reliable cleaning and preparation.

Nickel titanium instruments, when used with the crown-down technique, provide a conical form, retain the original canal form, and create minimal operational errors in working length (1,2). The ProFile® (Dentsply, Tulsa Dental, Tulsa, OK, USA) system of .06 NiTi rotary files is capable of providing well-centered, more circular preparations with a predefined standardized taper in the apical portion of the root canal system (3). Iqbal et al. (4) reported that ProFile® instruments create a minimum loss of working length and apical transportation. Ayar and Love (5) also indicated that ProFile® files provide an acceptable canal preparation because of minimum canal transportation. Zmener and Banegas (6) also reported that ProFile® files result in a preparation compatible with the original canal form.

Currently, one of the most widely used obturation techniques is lateral compaction. When used appropriately with no excess pressure, it helps to achieve correct canal obturation (7) with a minimal risk of apical leakage (8). With the cold conventional lateral compaction technique, .02 taper standard gutta-percha cones are utilized. Recently, however, gutta-percha cones with increased taper have been developed for use with rotary files, and it has been reported that the use of gutta percha cones having the same taper with nickel titanium instruments may reduce microleakage (9).

Various techniques have been used to evaluate leakage after root canal obturation. In the fluid filtration technique the quality of the obturation is evaluated under constant air pressure both coronally and apically. In a study by Wu et al. (10) it was shown that, since specimens subjected to fluid filtration techniques were not damaged, repeated experiments could conveniently be conducted.

The purpose of this study was to evaluate the coronal and apical leakage of root canal obturations by using the fluid filtration technique. The instruments used were stainless steel and motor-driven nickel titanium instruments and the root canals were obturated by the lateral compaction technique. The sealing abilities of standard gutta-percha cones and those of inclined gutta-percha cones, which were used with single-cone techniques, were compared.

Materials and Methods

One hundred freshly extracted, fully developed human maxillary anterior teeth with single, straight canals were used. A single operator performed the root canal preparations and fillings. After sectioning all teeth at the CEJ to provide a reproducible reference point, the apical patency was verified in each tooth with a #10 K-type file, and working length (WL) was established as 0.5 mm short of the canal length (CL), the point at which the #10 file was first visible at the apical foramen. Ten teeth, 5 as a positive group and 5 as a negative group, were set aside. The remaining 90 teeth were divided into 3 groups with 30 teeth in each.

In the first group the roots were prepared with stainless steel instruments and filled by the lateral compaction technique using .02 gutta-percha cones. In the second group the teeth were prepared with ProFile® instruments and filled by lateral compaction using .02 gutta-percha cones, and in the third group the teeth were prepared with ProFile® instruments and filled by the single cone technique using .06 gutta-percha cones.

Preparation of root canal

Group 1: Mechanical instrumentation of 30 roots was carried out with stainless steel files to a size 40 K-file as master apical file. A crown-down technique was used and the coronal 1/3 of roots was instrumented by using Gates-Glidden drills (Dentsply, Maillefer). Root canals were enlarged with size 40 K-file as master apical file.

Groups 2 and 3: Total 60 root canals were prepared with ProFile® rotary instruments using a high torque motor (Endo Torque, Medidenta International, USA) set at 350 rpm. The roots canals were prepared with the crown-down technique recommended by the manufacturer. Root canals were prepared to the working length at an apical size 40 and .06 taper. 2.5% NaOCl was used between each ProFile® rotary instruments.

Root canal obturation

Lateral compaction

In groups 1 and 2 the lateral compaction technique was used. The root canals were obturated with gutta-percha and AH26 sealer (Dentsply, Maillefer) using the cold lateral compaction technique. An ISO size 40 master gutta-percha cone was inserted into the root canal to the working length until tug-back was obtained. The AH26 sealer was prepared according to the manufacturer's instructions. The sealer was applied with a size 40 K-file used in a counterclockwise motion. The master gutta-percha cone was then coated with AH26 sealer and placed into the root canal to the working length. Lateral compaction with accessory gutta-percha cones was performed until the root canal was filled. The process was completed when the spreader could no longer penetrate more than 2 mm into the canal. Excess gutta-percha was removed with a heat source, and vertical force was lightly applied to compact the remaining mass.

Single cone

In group 3 the single cone technique was applied. The roots were filled with a size 40 .06 tapered single cone of gutta-percha (Sure-endo, Sure Dent Corp, Korea) with AH26 sealer. A size 40 .06 tapered gutta-percha cone was trimmed to give tug-back at working length. Sealer was first applied to the canal. The cone was coated in sealer and applied to the working length.

To evaluate apical and coronal sealing capabilities, the fluid filtration technique was utilized, and during this process the equipment designed by Çobankara et al. (11) was used. The sectioned root specimens were attached to an 18-gauge stainless steel tube. These root sections were inserted into the plastic tube from the coronal side for coronal measurements and were attached to the equipment from the apical side for apical measurements. For the purpose of preventing leakage, cyanoacrylate cement was applied circumferentially between the root and the plastic tube. Distilled water was used to fill all the pipettes, syringes and plastic tubes at the coronal and apical sides of the sectioned roots. For the measurement process, an air bubble was created in the micropipette and adjusted to an appropriate position with the syringe. Oxygen was applied to the apical side (for measurement of apical leakage) or coronal side (for measurement of coronal leakage). As a result of forcing water through the voids along the root canal filling, the air bubble in the capillary tube was displaced, and this displacement was recorded as the fluid transport. The volume of fluid transport was measured by observing the motion of the air bubble. The measurements were recorded at 2-min intervals for a duration of 8 min, and then the results were averaged. The flow rate through the 18-gauge needle in an unobturated canal was determined by weighing the water mass that could flow through the 18-gauge needle in 1 min, and this was found to be 1.850 g/min at 239 cm H_2O. This value served as a positive control. All values were calculated in comparison with the positive control group. The experiment was conducted under a standard pressure of 2 atmospheres.

The results of the study were evaluated statistically using one-way ANOVA and the Tukey HSD test.

Results

In this study, fluid leakage was observed in the positive control group, which had void root canals, and this leakage was recorded in units of $\mu l min^{-1}/cm\ H_2O$. On the other hand, the negative control group, which had all apical and coronal surfaces coated twice with nail polish, showed no leakage.

Evaluation of the instruments

One-way ANOVA was applied for evaluation of the leakage effects of root canal instruments. No statistically significant values were obtained for their effects on leakage. Although ProFile® rotary instruments seemed to lead to less leakage, the results were not statistically significant. The statistical data are given in Table 1.

Table 1 Statistical values of the instruments used

Groups	N	Mean	Standard Deviation
Stainless Steel	30	0.0020	± 0.0008
ProFile®	60	0.0017	± 0.0008

Evaluation of coronal leakage

Coronal leakage was evaluated by one-way ANOVA, and statistically significant differences were observed between some of the groups ($P < 0.05$). The Tukey HSD method was further applied to examine the groups showing differences, and this demonstrated that the differences between the previously defined Groups 1 and 2 were statistically significant ($P < 0.05$). The results are given in Table 2.

Evaluation of apical leakage

Apical leakage was evaluated by one-way ANOVA, and the results are presented in Table 3. There were no statistically significant differences between any of the groups.

Discussion

This study is the first to have evaluated the effects of ProFile® and stainless steel root canal instruments on leakage characteristics. Previous studies have indicated that ProFile® instruments, by retaining the original canal curvature and by creating less transportation, yield conical preparations (1). Thomson and Dummer (12) and Bryant et al. (13) have also reported appropriate shaping in root canal preparations with the use of ProFile® instruments.

The most important parameter for evaluating the effectiveness of instruments is their ability to deliver efficient cleaning and shaping while preserving the

Table 3 Statistical values on apical leakage

Groups	Mean	Standard Deviation
Stainless steel apical N = 15	0.0020	± 0.0010
ProFile® .02 apical N = 15	0.0018	± 0.0008
ProFile® .06 apical N = 15	0.0019	± 0.0010

Table 2 Statistical values on coronal leakage ($P < 0.05$)

Groups	Groups	Differences in means	Standard Deviation
Stainless steel coronal N = 15	ProFile .06 coronal	0.0001	± 0.0002
	ProFile. 02 coronal	0.0007(*)	± 0.0002
ProFile® .02 coronal N = 15	ProFile .06 coronal	-0.0006	± 0.0002
	Stainless steel coronal	-0.0007 (*)	± 0.0002
ProFile® .06 coronal N = 15	ProFile .02 coronal	0.0006	± 0.0002
	Stainless steel coronal	-0.0001	± 0.0002

(*) Statisticaly significant differences exist in these groups ($P < 0.05$).

curvature of the canal during the operation (14). Various studies have reported that the utilization of nickel titanium instruments, by causing less transportation than stainless steel instruments at both the middle and apical thirds, results in shaping at the apical third that closely resembles the original canal form (15). The literature also indicates that motor-driven nickel titanium instruments create canal shapes that are more circular and homogeneous in form (1). When enlargement of canals is required, it has been reported that stainless steel instruments create more uninstrumented regions (16).

Although the present study revealed no statistically significant differences between the effects of preparation on canal obturation, the microleakage values were found to be less for nickel titanium instruments. The highest levels of apical and coronal leakage were found in Group 1, which was instrumented with stainless steel instruments. This finding, although indirect, is thought to highlight the advantages of nickel titanium instruments for canal preparation and possible microleakage.

Since the utilization of .06 nickel titanium instruments creates a more homogeneous canal form and results in effective removal of irregularities, it is believed that this further helps the obturation material to adapt to the canal wall efficiently.

It has also been reported that nickel titanium instruments lead to a minimum level of iatrogenic damage (17). Glosson et al. (1) reported better shaping in the apical region when nickel titanium instruments were used. It is believed that these advantages of nickel titanium over stainless steel instruments may lead to less leakage in restored teeth.

Recently, lateral compaction has become one of the most widely used techniques for root canal obturation. This study compared the lateral compaction technique with the single cone technique employing inclined gutta-percha cones.

In order to improve the success of endodontic treatment, the root canal sytem should be obturated effectively both coronally and apically. Although a good apical barrier is important (18), insufficient coronal obturation may lead to bacterial contamination (19). For this reason, apical and coronal microleakage has become an important issue in endodontic research (20), and was therefore examined in the present study.

This study used the fluid filtration method for evaluation of leakage. One possible drawback of this method is the likelihood of damage to specimens (10,21), but this possibility was minimized in the present study using different specimens for evaluation of coronal and apical leakage.

Our results obtained using the fluid filtration method revealed a statistically significant difference in coronal leakage between the groups subjected to lateral compaction and with .02 gutta-percha cones. The only difference in the processing was the use of nickel titanium and stainless steel instruments. The data revealed that the nickel titanium instruments created a homogeneous canal form and were effective for removal of irregularities, thus aiding efficient adaptation of the obturation material to the canal wall. The lower level of leakage also indicated that a coronal preparation having a greater taper requires more accessory cones, and that a larger gutta-percha mass results in better compaction, and hence better adaption of the gutta-percha to the canal walls.

There were no statistically significant differences between the groups prepared with nickel titanium instruments but subjected to either lateral compaction or the single cone technique.

When all the groups were evaluated in terms of apical leakage, no significant differences were observed among the results for any of the groups. This shows that the lateral compaction technique and the single cone technique yield no significant differences in terms of apical microleakage. It is believed that in the lateral compaction technique, the spreader penetration provides satisfactory compaction. In the single cone technique on the other hand, the same effective apical compaction is attributed to the tapered gutta-percha cones. Although the literature on apical leakage in relation to lateral compaction and the single cone technique reports similar results, like those of Pérez Heredia et al. (9) and Gordon et al. (8), Yücel and Çiftçi (22) have also argued that the single cone technique creates more leakage than the lateral compaction technique.

In the present study, different amounts of apical and coronal leakage were observed in all of the groups. The highest level of leakage was observed coronally in the group instrumented with stainless steel files and obturated by lateral compaction. In contrast, the lowest level of leakage was recorded coronally in the group obturated by lateral compaction, but instrumented with ProFile® files. This finding is attributable to the known and previously reported advantages of ProFile® files over stainless steel files. When all the other parameters were kept fixed and only the root canal obturation techniques were evaluated, the groups obturated by lateral compaction yielded lower mean values of leakage than those obturated using the single cone technique.

Within the limits of this study, it is believed that, although the lateral compaction technique is widely used, the single cone technique can also be used with equal confidence for straight canals.

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