In Vitro Evaluation of Matched-Taper Single-Cone Obturation with a Fluid Filtration Method

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ABSTRACT

Objective: Widespread use of rotary nickel-titanium systems has caused manufacturers to produce gutta-percha cones that match the taper of the canals prepared with these systems. Obturations with these cones may provide 3-dimensional obturation of the root canal in less time. The aim of this study was to use a fluid filtration method to compare the apical sealing ability of matched-taper single-cone, Thermafil and lateral condensation obturations.

Materials and Methods: Sixty-six extracted human lower premolar teeth were instrumented to size F3 with ProTaper instruments. The teeth were divided into 3 groups and obturated with matched-taper single-cone, Thermafil and lateral condensation techniques. AH Plus was used as a sealer. Six teeth were used as positive and negative controls. A fluid filtration system was used to evaluate the apical seal. Measurements were made at 2-minute intervals for 8 minutes and the average of these values was recorded. One-way analysis of variance test was used for statistical analysis.

Results: Mean leakage values for the lateral condensation, single-cone and Thermafil groups were 0.49 ± 0.37 μL min^{-1}, 0.39 ± 0.24 μL min^{-1} and 0.44 ± 0.25 μL min^{-1}, respectively. The difference between the groups was not statistically significant ($p > 0.05$).

Conclusions: The apical sealing ability of matched-taper single-cone obturation was comparable with that of lateral condensation and Thermafil techniques.

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The most important factors for a successful root canal treatment are biomechanical instrumentation of the root canal, disinfection and dissolution of organic matter to eliminate bacterial pathogens, and 3-dimensional obturation of this space.[1]

In recent years, rotary nickel-titanium (NiTi) instruments have become popular because of their superiority over stainless steel hand files, elasticity and resistance to torsional fracture.[2] Moreover, rotary NiTi instruments improve working safety, shorten working time and prepare well-shaped root canals with fewer canal transportations.[3,4]

Recently, new file designs of rotary NiTi instruments with sharp cutting edges called ProTaper (Dentsply Maillefer, Ballaigues, Switzerland) were introduced. The ProTaper files were specially designed to provide superior flexibility and efficiency, and greater safety. These instruments have a convex triangular cross-sectional design, a noncutting safety tip and an advanced flute design that combines multiple tapers within the shaft.[3,5]

The ProTaper system features just 6 instruments: SX shaper, 2 shaping files (S1 and S2) and 3 finishing files (F1, F2 and F3).[3,6,7]

Although several techniques involving gutta-percha have been used for 3-dimensional homogenous filling, cold lateral condensation is still one of the most frequently used techniques.[8,9] Because of the widespread use of the rotary NiTi systems, manufacturers have produced gutta-percha cones that match the taper of canals prepared with these systems. Preparation of a root canal with rotary NiTi instruments and the use of a sealer with these cones may provide 3-dimensional obturation of the root canal in less time.[10] More recently, gutta-percha points for ProTaper (Dentsply Maillefer) have been introduced for simple, time-efficient obturation. In this system, root canals are prepared with the ProTaper instruments and filled with the point that fits the size of the finisher file. The manufacturer claims that ProTaper gutta-percha points perfectly fit canals that have been prepared with ProTaper files.

The aim of this study was to use a fluid filtration method to compare the apical sealing ability of matched-taper single-cone, Thermafil and cold lateral condensation techniques in teeth prepared with ProTaper instruments.

Materials and Methods

Sixty-six human lower premolar teeth that were extracted for periodontal and prosthetic reasons were used. The teeth had mature apices and a single-canal configuration. The crowns were removed at the cementoenamel junction with a diamond disc under water coolant. The roots were accessed and a size #15 K-file (Dentsply Maillefer) was inserted into the root canal. To determine the working length, a size #15 K-file was inserted into the root canals until it was visible at the apical foramen. The working length of each canal was calculated to be 1 mm short of that position.

All teeth were prepared with ProTaper NiTi rotary instruments to size F3. A total of 6 instruments were used with the X-Smart Device (Dentsply Maillefer) with a 16:1 reduction rotary handpiece X-Smart Contra-angle (Dentsply Maillefer); the speed of rotation was maintained at 250 rpm. Two millilitres of 2.5% sodium hypochlorite solution was used for irrigation between each file size. ProTaper files were used in the following sequence, according to the manufacturer's recommendations:

1. The pulp chamber was filled with sodium hypochlorite solution and the S1 file was used to enlarge the coronal two-thirds of the canal.
2. The canal was re-irrigated and the SX file was inserted into the canal until it encountered light resistance. Shaping with the SX was continued with a brushing motion until two-thirds of its cutting blades were below the orifice.
3. The canal was irrigated and a size 10 K-file was used for recapitulation.
4. Shaping continued with the S1 file to the working length.
5. Then the S2 file was taken to the working length.
6. The F1 file was taken to the full working length and immediately withdrawn.
7. The F2 file was taken to the full working length.
8. The F3 file was taken to the full working length.

After the preparation procedure was completed, the teeth were randomly divided into 3 groups, each consisting of 20 samples. The remaining 6 teeth were used as positive and negative controls. AH Plus (Dentsply DeTrey, Konstanz, Germany) was used as a sealer and the root canals were obturated as follows:

Group 1: with the matched-taper single-cone (gutta-percha for ProTaper, size F3) technique

Group 2: with the cold lateral condensation (Diadent ML.029, Korea) technique

Group 3: with the Thermafil (Dentsply Maillefer) technique

Matched-Taper Single-Cone Obturation

A size F3 gutta-percha cone (Dentsply Maillefer) was prefitted into the root canal at the working length. Then the canal was dried with paper points (Meta, Meta Dental Co., Seoul, South Korea) and AH Plus was applied to the root canal walls with a size 30 K-file. Then the cone was lightly coated with the sealer and placed into the canal to the working length. The excess gutta-percha was removed with a heated instrument and the canal orifice was sealed with Cavit-G (3M ESPE, Seefeld, Germany).

Cold Lateral Condensation Obturation

A size #30 .02 taper gutta-percha cone (Dentsply Maillefer) was prefitted into the canal at the working length. The canal was dried, and AH Plus was applied to the canal walls. The master cone was coated with the sealer and placed into the canal at the working length. Lateral condensation was done with accessory cones and finger spreaders. Lateral condensation was completed when the spreader could no longer penetrate into the canal. Excess gutta-percha was then removed with a heated instrument and access cavities were sealed with Cavit-G.

Thermafil Obturation

A size #30 verifier was prefitted into the canal at the working length. The same size Thermafil obturator was heated in the ThermaPrep Plus Oven (Dentsply Maillefer, Holland). The canal was dried, and AH Plus sealer was applied to the coronal portion of the canal. Then the obturator was slowly placed at the working length in a single motion. After the gutta-percha was cooled, the

obturator was severed at the canal orifice and the canal was sealed with Cavit-G.

After obturation, all teeth were stored at 37°C, 100% humidity, for 7 days to allow the sealing materials to set fully.

In the experimental groups, all root surfaces except the apical 2 mm were covered with 2 coats of nail polish. Specimens selected for positive (n = 3) and negative (n = 3) control groups were instrumented in the same way as the specimens for the experimental groups, but the root canals were not obturated in the positive control group to allow 100% leakage. The root surfaces of these teeth were also coated with 2 layers of nail polish, except the apical 2 mm. The teeth in the negative control group were obturated with lateral condensation, single-cone or Thermafil techniques, and all root surfaces were covered with 2 layers of nail polish to ensure there was no leakage.

A modified fluid filtration method[11–13] was used to test the roots. The root was mounted in a plastic tube from the apical end and was stabilized tightly with cyanoacrylate glue. The plastic tube was attached to a micropipette filled with deionized water. All connections of the testing apparatus were also tightly closed with the cyanoacrylate glue. The fluid filtration test was conducted under 1 atm of pressure. An air bubble was introduced into the system with an air syringe and positioned with a water syringe. The system was closed with hemostats. The apical sealing ability of the obturation techniques was quantitated by the movement of the bubble in the micropipette. The measurements were made at 2-minute intervals for 8 minutes, and the average value was recorded. Leakage values were expressed as μL min^{-1} with their standard deviations.

The differences in fluid transport between the groups were statistically analyzed with one-way analysis of variance test. The level of significance was set $\alpha = 0.05$.

Results

Mean leakage values for the 3 groups are shown in **Table 1**. Although the lateral condensation group showed more leakage than the matched-taper single-cone or Thermafil groups, the difference among the 3 root canal obturation techniques was not significant ($p > 0.05$).

Table 1 Mean leakage values for the 3 obturation techniques

Group (n = 20)	Mean leakage (μL min^{-1})[a]	Standard deviation
Lateral condensation	0.49	0.24
Matched-taper single-cone	0.39	0.24
Thermafil	0.44	0.25

[a]*As measured by fluid filtration.*

Discussion

The single-cone technique consists of a single gutta-percha cone filled at room temperature with sealer layer thicknesses that vary, depending on the adaptation of the single cone to the walls of the canal.[14] Single-cone obturations have not been well regarded because of the use of large amounts of sealer. Porosities in large volumes of sealer, setting contraction and dissolution of the sealer are the main disadvantages of this technique.[15] The poor seal and success of the material because of shrinkage after setting is a significant problem.[16]

It has been reported that obturations of lateral condensation had a better treatment outcome than single-cone obturations.[17] However, these obturations were done with standardized .02 taper gutta-percha cones, usually with zinc-oxide-eugenol-based sealers. Because large volumes of this soluble sealer were used, dissolution of the sealer may have had a negative effect on the outcome.[14] In this study, AH Plus sealer was chosen because of its low solubility. Schäfer and Zandbiglari,[18] who compared the solubility of resin, silicone, calcium hydroxide, zinc-oxide-eugenol- and glass-ionomer-based sealers in water and artificial saliva, reported that AH Plus lost the least amount of weight of all sealers tested in all liquids. Pommel and Camps[19] compared single-cone, lateral condensation, vertical condensation, Thermafil and System B techniques using a zinc-oxide-eugenol-based sealer and reported that the single-cone technique had the highest leakage. On the other hand, Wu and colleagues[14] studied the leakage of single-cone fillings using a silicone-based sealer for 1 year and concluded that single-cone fillings prevented fluid transport for 1 year.

With the widespread use of rotary NiTi instruments, matched-taper gutta-percha cones were developed and the single-cone technique has become popular again. Gordon and colleagues[10] reported that the cross-sectional area of the .06 taper single-cone technique was comparable with that of lateral condensation, and the taper single-cone technique was faster than lateral condensation. Bal and colleagues[20] compared the sealing ability of root canals prepared with .06 rotary NiTi instruments and obturated with either a .06 or a .02 tapered gutta-percha master cone using lateral condensation and found no difference between the groups. More recently, Zmener and colleagues[21] prepared the root canals using a rotary system and obturated with single-cone and lateral condensation techniques. They reported that with the use of a methacrylate-based sealer, the difference between single-cone and lateral condensation obturation was not significant.

A variety of materials and techniques have been developed to improve the quality of root canal obturations. However, none of these materials and techniques provides a leakproof seal.[22] Pashley[23] stated that microleakage is a serious clinical problem because most dental materials exhibit varying degrees of microleakage. The most important prerequisites of endodontics are total debridement of the pulpal space, development of a fluid-tight seal at the apical foramen and total obliteration of the root canal.[24] Therefore leakage tests are a relevant way to evaluate the apical seal. Methods used to evaluate apical leakage include dye-penetration, electrochemical, radioisotope, bacterial leakage and fluid filtration methods. Among them, the fluid filtration method has several advantages: the samples are not destroyed, thus permitting measurements over time, and no tracer is needed for the related problems of molecular size, affinity for dentin or pH.[25] Because of this, the fluid filtration method was chosen in this study.

In the current study, the results of matched-taper single-cone obturation were comparable with those of the lateral condensation and Thermafil techniques. However, the teeth used in this study had single straight canals but posterior teeth have narrow and curved canals with complex anatomy, which might present greater challenges. Further study is needed to evaluate the sealing ability of obturations of matched-taper gutta-percha cones to determine whether these obturations will have an acceptable apical seal.

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