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In Vitro Comparison of Apical Micro Leakage in Root Canal Prepared Wave One and Reciproc Files

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Abstract

A good apical seal is one of the criteria for the success of the endodontic treatment. The most common causes of failure in endodontic treatment are referred to the lack of proper apical seal. The aim of this in vitro study was to evaluate the apical sealing ability where the canals were prepared by wave one and recipro systems. Material & Method: Fifty one extracted human teeth with single root were divided randomly into 3 similar groups of fifteen of each. Group I: the teeth were instrumented with wave one (Dentsply Maillefer, Ballaigues, Switzerland), Group II: the teeth were instrumented with reciproc (VDW, Munich, Germany), and group III: the teeth were instrumented by hand instruments of K-files (Dentsply,maillefer,switzerland); then, the teeth were obturated with lateral condensation techniques. Six teeth were divided as positive and negative control groups; three in each one. AH26 was used as a root canal sealer in this study. A dye penetration method was used to evaluate the apical seal after the longitudinal section, using stereomicroscope at 40X magnification. The data were analyzed using ANOVA and LSD post-hoc test at 0.05 level of significance. Results: The Lsd statistical analysis of the results demonstrated that there was no statistically significant difference in micro leakage between the two different rotary instruments in each wave one and reciproc. While there was a significant difference between the rotary instruments, and the Hand instrument K-files. Conclusion: It could be concluded from this study that the use of the NiTi rotary instrument for root canal preparation showed the least apical micro leakage, in comparison with the hand instrument.

Keywords: Canal preparation, Apical seal, Wave one and recipro files.

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Introduction

The optimal obturation of the root canal system is one of the most important goals of endodontic treatment. The optimal obturation prevents the influx of microorganisms and tissue fluids into the root canal system (Genç Ö and Alaçam, 2011; Wu M-K and Fan, 2000). It also impairs the nutritional supply of the residual microorganisms in the root canal system, and subsequently prevents the leakage of toxic metabolites from the periapical tissues (Wu M-K and Fan, 2000; Taşdemir et al., 2009). The absence of apical seal is the most common cause of root canal treatment failure (Ingle, Bakland and Baumgartner, 2008; Veríssimo, 2006). A hermetic seal can increase the success of endodontic treatment to 96% (Ingle, Bakland and Baumgartner, 2008). The absence of apical seal results in the leakage of tissue fluids into the root canal system through the apex, and leads to root canal treatment failure (Pommel, Jacquot and Camps, 2001).

To date, a number of instruments and techniques have been introduced for root canal instrumentation. During the recent years, rotary nickel-titanium (NiTi) instruments have become increasingly popular due to faster, easier and more predictable root canal shaping and lower frequency of procedural errors (Tan and Messer, 2002). Moreover, the use of flexible NiTi instruments enables better adaptation of gutta-percha to root canal walls due to less straightening of the canal compared with the use of stainless steel files (Taşdemir et al., 2009). The preparation of the apical region by different instrumentation systems and the

remaining debris on dentinal walls after instrumentation affect the adaptation of root filling materials to canal walls, and can eventually result in microleakage (Genç and Alaçam, 2001).

Since the quality of obturation is related to the quality of root canal preparation, the procedural errors should be minimized. The reciprocating single file systems enable root canal preparation with the use of only one file, and it has been claimed that these systems decrease the procedural errors compared with the multiple file systems (Yoon et al., 2015).

The Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) single file systems were introduced according to the reciprocation concept. WaveOne files have a triangular-shaped cross-section (Kardon et al., 2003), and are available in different sizes of small (yellow, 21.06) for use in narrow canals, primary (red, 25.08) for use in the majority of canals, and large (black, 40.08) for use in wide canals. They have a rotational angle of 170° in counter-clockwise direction, and 50° in clockwise direction operating at 350 rpm.

The Reciproc files have a S-shaped cross-section, and are available in different sizes of R25 (red, 25.08), R40 (black, 40.06) and R50 (yellow, 50.05). The rotational angle is 150° in counter-clockwise direction, and 30° in clockwise direction operating at 300 rpm (Tamse, Katz and Kablan, 1998).

Several techniques have been available for assessment of apical microleakage in vitro such as the dye penetration technique (Ahlberg, Assavanop and Tay, 1995), fluid filtration technique (Gale and Darvell, 1997), bacterial leakage technique (Tanomaru Filho, Figueiredo and Tanomaru, 2005), electrochemical method (Kubo et al., 2008) and radioisotope labelling (Shantiaee et al., 2016); among which, the dye penetration technique has been the most commonly used method for this purpose, which does not require complex advanced equipment (Wu M-K, Kontakiotis and Wesselink, 1998).

Leonardo et al. (2004) evaluated the apical seal of canals prepared with different rotary files, and filled with two thermoplastic methods using the dye penetration technique, and concluded that all rotary instruments and obturation systems cause different degrees of apical leakage.

Tasdemir et al. (2009) reported that canals prepared with ProTaper and Mtwo rotary systems and filled with three different obturation techniques (warm vertical condensation, lateral compaction and single cone obturation) showed equal apical seal using the bacterial leakage test.

Genç et al. (2011) evaluated the apical microleakage of canals prepared with three different instrumentation systems (S-Apex, Light Speed and manual technique) using the fluid filtration method and concluded that the amount of apical leakage was the same in all groups.

Ismail et al. (2013) evaluated apical microleakage of canals prepared with RaCe and ProTaper rotary files and hand files using the dye penetration method, and found no significant difference between the two rotary file systems, while a significant difference was noted between the hand files and rotary systems. Tomer et al. (2016) evaluated apical microleakage of three rotary systems (WaveOne, F360 and ProTaper) and five obturation techniques (lateral compaction, single cone obturation, Calamus, Obtura and Thermafil) using dye penetration technique, and concluded that the three tested rotary systems were not significantly different in apical microleakage of prepared canals. Root canals filled with Calamus and Thermafil showed the lowest apical microleakage. Yoon et al. (2015) compared the percentage of gutta-percha-occupied area and its association with presence/absence of tug back using Reciproc and WaveOne rotary systems, and found no significant difference between the two rotary systems neither in tug back, nor in the size of gutta-percha points. They used micro computed tomography for their assessment.

Studies regarding the geometry and physical structure of rotary files and their role in apical microleakage of root canals have been limited. Thus, this study aimed to compare the apical microleakage of root canals prepared with WaveOne and Reciproc rotary systems using the dye penetration technique to find files resulting in superior apical seal.

Materials and Methods

This study evaluated 51 human single-rooted premolars with straight root canals and mature apices. The teeth had been extracted for orthodontic or periodontal reasons. The study was approved in the Ethics Committee of Zahedan University of Medical Sciences (IR.ZAUMS.REC.1395.7). The teeth were radiographed from the mesiodistal and buccolingual directions, and evaluated under a microscope (Zeiss, Oberkochen, Germany) at x20 magnification to ensure the absence of root caries, fracture, additional canals, calcification, internal or external root resorption and severe curvature. The teeth with such defects were excluded, and replaced with sound teeth. Tissue residues and calculus were removed, and the teeth were immersed in 2.5% sodium hypochlorite for 2 hours. They were then immersed in saline at 4°C until the experiment. The crowns were cut at the cementoenamel junction (CEJ) using a multipurpose bur (Dentsply Maillefer) and high-speed hand-piece under air and water coolant. The root length was adjusted at 16 mm. Apical patency was maintained using a #15 K-file (Dentsply Maillefer, Switzerland). To determine the working length, the file was introduced into the canal until its tip was visible at the apex; 1 mm was subtracted from this length to determine the working length. The selected teeth were randomly divided into three groups of 15. The remaining six teeth were assigned to positive and negative control groups (n=3). The teeth with apical foramen size larger than #25 hand file with 2% taper were excluded and replaced.

Group 1 (WaveOne): WaveOne file #25 with 0.08 taper with an endo motor (Dentsply Maillefer, Ballaigues, Switzerland) was used with reciprocating technique and slow in-and-out pecking motion according to the manufacturer's instructions.

Group 2 (Reciproc): Reciproc file #25 with 0.08 taper with an endo motor (VDW. Silver Reciproc Endo Motor, VDW, Munich, Germany) was used with reciprocating technique and slow in-and-out pecking motion according to the manufacturer's instructions.

Group 3 (manual technique): The teeth were instrumented with hand files (Dentsply Maillefer, Switzerland) using the step-back technique. They were filed up to file #25 (2%) and flared up to file #80.

Each canal was rinsed with 5.25% sodium hypochlorite between files with an irrigating syringe with 27-gauge needle. Apical patency was ensured after using each instrument using a #10 K-file. After the preparation of the canals, they were rinsed with 10 mL of 5.25% sodium hypochlorite (Cerkamed; Poland), and were then rinsed with 10 mL of 17% EDTA (Fórmula & Ação, São Paulo, Brazil) for 1 minute for smear layer removal. Eventually, the canals were dried with paper points. Standard-size gutta-percha point (ISO#35,30) was placed in the root canal to the working length along with the tug back. AH26 sealer (Dentsply, DeTrey, Zürich, Switzerland) was mixed according to the manufacturer's instructions.

A Lentulo spiral size 2 with 25 mm length (Mani, Japan) was dipped in sealer, and introduced into the canal with a low-speed hand-piece 1 mm short of the working length, and used for 4 to 6 times at low speed and up-and-down rotary movements. Excess sealer in the apical and coronal regions was cleaned by a gauze.

The master cone was dipped in AH26 sealer, and gently inserted into the canal to the working length. Accessory gutta-percha points (ISO#20,25) were placed in the canal, and compacted laterally using a #30 finger spreader (Dentsply Maillefer) until the spreader could not be inserted into the canal for more than 3 mm. After the completion of obturation, gutta-percha was removed from the coronal orifice to the CEJ using a hot instrument, and the root filling was vertically condensed using a plugger (Dentsply/Maillefer) selected according to the coronal diameter of the prepared root canal. The access cavity was sealed with glass ionomer cement. The teeth were radiographed from mesiodistal and buccolingual directions to assess the quality of root filling. The filled root canals were incubated at 37°C and 100% humidity for 7 days in order to allow a complete setting of sealer prior to leakage test.

In the experimental groups, the entire root surface except for the apical 2 mm was coated with two layers of nail varnish. In the positive control group, root canals were not filled to allow maximum leakage. The root surface of these teeth was also coated with two layers of nail varnish except for the apical 2 mm. In the negative control group, the filled canals were coronally sealed with light-cure glass ionomer and apically sealed with wax, after being coated with two layers of nail varnish. This was done to ensure no leakage. All samples were then immersed in a glass container containing 2% methylene blue with a pH of 7.0 (phosphate buffered saline was used), and incubated at 37°C for 72 hours. They were then rinsed under running water. Nail varnish and sticky wax were removed from the root surface by a scalpel, and the teeth were air dried. A shallow longitudinal groove was created buccolingually using a diamond disc with a small diameter under water and air spray. The teeth were then split in half using a chisel.

Two observers inspected the linear penetration of dye through the apex under a stereomicroscope at x40 magnification, and recorded the mean value for each tooth.

Descriptive data were reported in tables, and diagrams and measures of central dispersion were all reported. Data were analyzed using ANOVA and LSD post-hoc test at 0.05 level of significance. The data were analyzed using SPSS version 19.

Results

A total of 51 extracted human premolars were evaluated in this study; out of which, 15 teeth were assigned to the Reciproc group, 15 teeth were assigned to the WaveOne, and 15 teeth were assigned to the hand instrumentation group. Six teeth served as the positive and negative controls (n=3).

The results showed that the maximum mean of apical microleakage occurred in hand instrumentation (control) group in an amount of 5.61±2.26.

The Shapiro-Wilk test was used to assess normal distribution of data, which showed that the data were normally distributed. Thus, ANOVA was applied to analyze the data .

The LSD post-hoc test showed that the WaveOne and Reciproc groups were not significantly different (P>0.05) but WaveOne and Reciproc had significant differences with the control group (P=0.001). Table 1 shows the mean microleakage of WaveOne and Reciproc groups.

Table 1. Mean, standard deviation, minimum and maximum microleakage in millimeters in each group

Leakage	N	Mean	Std. deviation	Minimum	Maximum	P
Hand instrumentation	15	5.6167	2.26752	2/00	9/50	0.001
Reciproc	15	2.4167	0.98046	0/00	4/00	
Wave one	15	3.1000	1.40089	0/00	5/25	
Total	45	3.7111	2.12196	0/00	9/50	

Discussion

The main goal of root canal filling was to obstruct the canal path, and create a hermetic seal in the apical region to prevent leakage of bacteria and their products into the root canal system from all possible routes (Kardon et al., 2003). Complete debridement of the root canal system and creating a fluid-tight seal in the apical

foramen along with complete filling of the root canal system are important prerequisites for a successful endodontic treatment (Taşdemir et al., 2009).

Several dyes at different concentrations have been used for the assessment of microleakage such as 5% eosin solution (Tamse, Katz and Kablan, 1998), India ink (Tamse, Katz and Kablan, 1998; Ahlberg, Assavanop and Tay, 1995), silver nitrate (Gale and Darvell, 1997), methylene blue (Tamse, Katz and Kablan, 1998; Tanomaru Filh, Figueiredo and Tanomaru, 2005) and rhodamine B (Tanomaru Filh, Figueiredo and Tanomaru, 2005). Dyes can chemically react with the sealers or dentin; this can affect their infiltration, and cause their color change (Kubo et al., 2008). Apical microleakage is influenced by a number of factors such as different root filling techniques, chemical composition of sealer and presence/absence of smear layer (Shantiaee et al., 2016). In this study, 2% buffed methylene blue was used. Methylene blue is composed of fine sub-micron size particles that enhance the accuracy of testing because if these particles cannot pass through the gap between the canal wall and gutta-percha points, it is obvious that larger particles such as bacteria and their endotoxins cannot pass either (Ørstavik, Eriksen and BEYER-OLSEN, 1983). Also, methylene blue is susceptible to oxidation, and can become colorless in contact with sulfuric acid or zinc (Kubo et al., 2008). For instance, Seal Apex is a calcium hydroxide-based endodontic sealer that contains zinc oxide and reducing agents that can decolorize the methylene blue (Wu M-K, Kontakiotis and Wesselink, 1998). Evidence has shown that methylene blue with a pH≤5 can cause dentin demineralization and allow dye penetration. Thus, phosphate buffered saline has been used to increase the pH of solutions to 8, and prevent changes in pH (Wu and Wesselink, 1993; Starkey, Anderson and Pashley, 1993).

Kubo et al. (2008) used 2% buffered methylene blue to prevent a reaction between dye and AH Plus sealer and also to prevent release of particles from the cement into the dye solution. Similarly, AH26 sealer (Dentsply, Tulsa Dental, Tulsa, OK, USA), which has been among the most commonly used epoxy resin sealers with high sealing ability, was used (Khalilak et al., 2011).

This study aimed to assess the apical microleakage in canals prepared with WaveOne, Reciproc and hand files and filled with lateral compaction technique using the dye penetration test. Despite the complexities and differences in the root canal morphology, it was tried to standardize the groups. All teeth were evaluated in terms of apical size, root canal length (distance from the apex to the CEJ) and other inclusion and exclusion criteria by initial radiography and microsocial observations.

The presence of smear layer is among the main causes of leakage between the root canal wall and root filling material (Saunders et al., 1992), because the smear layer limits the efficient penetration of disinfecting agents, and compromises an optimal seal. It also irritates the peri-radicular tissues, and due to its weak adhesion and low density, provides a path for leakage (Jadhav et al., 2016).

In the present study, 5.25% sodium hypochlorite and 17% EDTA were used for smear layer removal because the organic and inorganic particles of the smear layer are soluble in sodium hypochlorite and acid; respectively (Depraet, De Bruyne and De Moor, 2005). Elimination of debris and smear layer depends not only on the method of irrigation, but also on the endodontic instrument design (size, taper, cross-section) and method of using the instrument (rotational or vibrational) (Jadhav et al., 2016). The ability of single file systems in cleaning of the root canal system is equal or superior to that of multi-file systems. Evidence has shown that the lower the amount of debris created during the instrumentation, the higher the adaptation of root filling materials and the lower the apical leakage would be (Pedullà et al., 2013). Thus, the smear layer was eliminated in this study to inhibit its effects on leakage.

Maintaining the root canal anatomy is important for 3D root canal obturation. At present, the use of M-wire alloys (used in Reciproc files) has improved the properties of the conventional NiTi files. A previous study showed that Reciproc system can better preserve the root canal anatomy in the middle and apical thirds compared with other rotary systems; although this difference was not significant (Rubio, Zarzosa and Pallarés, 2017). Some others showed higher dye leakage after flaring of the apical region (Mente et al., 2007; Gomes-Filho et al., 2008). Thus, it might be concluded that Reciproc causes less changes in the root canal geometry and enables safer obturation and sealing of the root canal system; thus, the apical leakage would be minimized.

The current results revealed significantly higher apical leakage in teeth prepared with hand files compared with those prepared with rotary files; this finding was in agreement with the results of Ismail et al (2013). The reason might be the inevitable change in the canal geometry in the apical region when stainless steel hand files are used, which contributes to greater leakage. On the other hand, Genç et al. (2011) compared apical microleakage of two rotary instrumentation systems (S-Apex and LightSpeed) in comparison with hand instrumentation. They found no significant difference in apical microleakage between the groups, which was in contrast the findings of this study. In the current study, apical microleakage of WaveOne (3.1000 mm) and Reciproc (2.4167 mm) was not significantly different; this finding was similar to that of Tasdemir et al, (2009) who compared Mtwo and ProTaper rotary systems, and Tomer et al, (2016) who used WaveOne, ProTaper and F360 file systems. Yoon et al. (2015) used WaveOne and Reciproc for canal instrumentation, and filled the canals with single cone technique (#25/8% and #30/6% gutta-percha). They found no significant difference between the two rotary systems in the percentage of gutta-percha-occupied area. They used micro computed tomography in their study, and reported 19% space discrepancy between the gutta-percha points and root canal walls after the instrumentation with reciprocating NiTi rotary files, which was due to the mechanical properties of the instrument or the repetitive pecking movements; this could have contributed to apical preparation larger than the actual file size. Such a space discrepancy can decrease the adaptation of gutta-percha master cone to the root canal walls (Yoon et al., 2015). As mentioned earlier, the magnitude of apical flaring and

dye leakage were correlated. According to their findings, it may be concluded that the number of pecking movements during root canal instrumentation should be controlled.

Conclusion

The current results revealed that root canals instrumented with reciprocating single files and filled with gutta-percha and sealer with lateral compaction technique would have minimal apical microleakage.

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