Original Article

Influence of Prior Cervical Enlargement on Apical Cleaning Using Single File

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Received 14 November, 2014/Accepted for publication 15 January, 2015

Abstract

The goal of this study was to compare the apical cleaning capabilities of single files from 3 different rotary systems in the presence or absence of prior cervical preparation based on a histological analysis. A total of 84 human single-rooted mandibular permanent incisors were divided into 6 groups (14 canals each). Cleaning and shaping was performed under the following protocols: Group I, F2 ProTaper at working length; Group II, SX ProTaper and F2 ProTaper; Group III, size 25, .06 taper Mtwo at working length; Group IV, SX ProTaper and size 25, .06 taper Mtwo; Group V, size 25, .06 taper BR3 BioRace at working length; and Group VI, SX ProTaper and size 25, .06 taper BR3 BioRace. After cleaning and shaping, the root canals were evaluated by histological analysis. The percentage of remaining debris was evaluated using a cross-hatched grid superimposed over each image. Data were assessed using the Shapiro-Wilk and ANOVA tests. Statistically significant differences were observed between groups ($p=0.0001$) with respect to amount of remaining debris; use of SX in conjunction with F2 ProTaper yielded a significantly lower mean percentage of debris. It was concluded that cleaning ability improves when root canal preparation with F2 ProTaper is complemented by prior cervical enlargement.

Key words: BioRace — Continuous rotating motion — ProTaper — Root canal preparation

Introduction

Ideally, endodontic treatment should include complete removal of all pulp tissue, necrotic dentin, and microorganisms, to be achieved by enlarging the root canal to obtain a clean, deformation-free area ready for posterior filling with endodontic sealer and gutta percha points^{3,18)}. Currently, this is not possible, how-

ever, as no available preparation technique will allow the root canal to be completely cleaned, particularly in the anatomical region of the apical third. This means that the clinical success of the endodontic treatment may be undermined^{10,12)}.

Several types of endodontic rotary instrument have been developed with a view to optimizing such treatment, which has led

Table 1 Groups according to root canal preparation protocol

Group	Protocols for preparation
I	F2 (ProTaper, Dentsply Maillefer, Ballaigues, Switzerland) at WL of 19 mm
II	SX (ProTaper) at WL of 12 mm and F2 at WL of 19 mm
III	Mtwo 25, .06 (Mtwo, VDW, Munich, Germany) at WL of 19 mm
IV	SX at WL of 12 mm and Mtwo 25, .06 at WL of 19 mm
V	BR3 25, .06 (BioRace, FKG Dentaire, La Chaux-de-Fonds, Switzerland) at WL of 19 mm
VI	SX at WL of 12 mm and BR3 25, .06 at WL of 19 mm

WL: working length

to the gradual replacement of manual with mechanical instruments^{10,17,22}. Such rotary instruments are designed to facilitate faster, higher-quality root canal preparation, reducing stress on both the professional and the patient during endodontic therapy^{4,7,28}. These instruments first came onto the market in the mid-1990s, since which they have undergone constant refinement thanks to new manufacturing processes^{14–16}. These changes in manufacturing have allowed variation in taper format, cross-section, and cut angle design. Such refinements have improved cutting ability and resulted in a gradual decrease in the number of instruments required during endodontic treatment⁶. Therefore, recent studies have proposed protocols that recommend the use of a single file for root canal preparation^{13,29}.

Although the recent focus has been on the use of simplified techniques using only one file, no consensus has been reached on the comparative cleaning efficiency of each type of instrument^{8,9,29}. The purpose of the present study was to compare the apical cleaning capabilities of single files from 3 different rotary systems in the presence or absence of prior cervical preparation based on a histological analysis. The hypothesis tested was that prior cervical preparation would increase cleaning efficiency.

Materials and Methods

1. Specimen selection

The study protocol was approved by the Ethics Committee of this institute (approval no: 147/2010). A total of 84 single-rooted freshly extracted human mandibular permanent incisors with fully formed apices were randomly selected from the Teeth Bank at the Dental School of Positivo University. All teeth were stored in aqueous 0.1% thymol solution at 9°C prior to use. Radiographs were taken in the buccolingual and mesiodistal projections to select those with only one root canal.

2. Root canal preparation

The incisal edge of each tooth was ground with a bur to obtain a standard length of 20 mm. The root canal was then accessed and negotiated using a #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) to obtain a working length of 19 mm. Two specimens ($n=2$) were used for the negative control group, which comprised uninstrumented and unirrigated root canals. The specimens were then randomly assigned to one of 6 groups ($n=14$ per group) and the following protocols undertaken by a single operator (Table 1).

The SX ProTaper was used in a brushing motion at a working length of 12 mm and the F2, size 25, .06 taper Mtwo, and 25, .06 taper BR3 BioRace at a working length of 19 mm.

During the procedure, each instrument was cleaned with gauze to remove debris and reinserted 5 times to the working length. The root canals were irrigated with a total of 20 ml of 2.5% NaOCl solution delivered using a syringe with a 27-gauge needle (Ultradent, South Jordan, USA) at 2 mm from the working length. Each instrument was used only once in a VDW Silver electric motor (VDW, Munich, Germany) at a speed of 300 rpm and a torque of 2 N·cm. On completion of instrumentation, each root canal was irrigated with 2 ml of 17% EDTA solution.

3. Histological preparation of specimens

After cleaning and shaping, the root canals were dried with paper points. The samples were then fixed in 10% buffered formalin for 48 hr and sent to a histopathology laboratory for analysis. Each specimen was decalcified in 20% formic acid and sodium citrate over 20 days, after which they were washed with tap water, dehydrated, diafanized, and embedded in paraffin. The specimens were hemi-sectioned perpendicularly to the long axis of the tooth to obtain a representative portion of the third apical region, which measured 3 mm vertically. Serial sections of 4 μ m were obtained using a microtome RM2155 (Leica Microsystems GmbH, Nussloch, Germany) and stained with hematoxylin and eosin to facilitate histomorphological and histomorphometric evaluation. Approximately 100 histological slices were obtained from each sample and analyzed using the BX-51 light microscope (Olympus, Tokyo, Japan) at 10 $\times$ magnification.

4. Histomorphological and histomorphometric evaluation

The percentage of remaining debris was evaluated using a cross-hatched grid superimposed over each image. Using the Image Tools 3.0 software (UTHSCSA, San Antonio, USA), the quadrants superimposed onto the root canal area were scored *via* a tag and count tool. Only those quadrants superimposed onto areas containing debris in the root canal were counted to establish debris percentage

and cleaning capability.

5. Statistical analysis

Data were assessed with SPSS Statistics version 20.0.0 (IBM Corporation, Armonk, USA) using the Shapiro-Wilk test. Once a normal distribution had been confirmed, the data were evaluated using a single-factor ANOVA followed by the Tukey test. In all tests, $p < 0.05$ was deemed to indicate statistical significance.

Results

The remaining debris can be observed in Fig. 1. The negative control group is shown in Fig. 1A. Table 2 expresses the results. No file deformation or breakage was observed.

Discussion

The purpose of this study was to determine whether cervical preflaring influenced apical cleaning when using only one instrument in this region. The results showed a statistically significant difference when prior cervical preparation was performed in association with the ProTaper F2. The proposed hypothesis was partially confirmed, as among most groups no statistically significant difference was observed in efficiency of apical cleaning.

If the initial apical file fits the apical third, then a larger master file can be used, thus allowing greater root canal enlargement and irrigant volume, which in turn influences the degree of cleanliness that can be obtained. To determine the appropriate master apical file size, cervical preflaring should be performed before choosing the initial apical file, as an appropriate fit is important in facilitating root canal enlargement²⁴. It is important to verify whether the appropriate size of file has been chosen when using the single file technique, and whether cervical preflaring would improve its performance in the apical area.

In this study, the ProTaper F2 yielded better results when used after the SX. The

Fig. 1 A: Negative control group showing apical third full of debris (asterisks); B: Apical third with dentinal surface non-instrumented (arrow); C: Apical third with dentinal surface non-instrumented (arrows); D: Apical third with dentinal surface non-instrumented (arrows); E: Apical third with presence of debris (asterisk) and dentinal surface non-instrumented (arrows) — (H.E. — 10× magnification)

use or non-use of the SX in the ProTaper groups made a difference to the results. No significant difference was observed with its use, however, in any of the other groups. This may be explained by the design features of the F2, such as its 8% taper from D1 to D3, while the Mtwo and BR3 both have a 6% constant taper. The results for the Mtwo and BioRace groups may also have been

influenced by the use of a second instrument immediately after using another instrument from the same system in the apical third, which constitutes part of that system's complementation design. Moreover, the results exhibited by the ProTaper F2 group do not represent optimum cleaning conditions, as some debris still remained. In this study, the root canals were prepared with ProTaper

Table 2 Percentage of remaining debris (mean and standard deviation) in apical third prepared using single file in presence or absence of prior cervical enlargement (n = 14)

Group	Debris mean (SD)
I: F2	(4.5 ± 2.2%) ^b
II: SX + F2	(2.6 ± 1.4%) ^a
III: Mtwo 25, .06	(5.4 ± 1.5%) ^b
IV: SX + Mtwo 25, .06	(4.3 ± 1.2%) ^b
V: BR3 25, .06	(5.0 ± 2.2%) ^b
VI: SX + BR3 25, .06	(3.2 ± 1.1%) ^b

a: groups with letters "a" were not significantly different by Tukey test ($p > 0.05$)

b: groups with letters "b" were not significantly different by Tukey test ($p > 0.05$)

F2 according to the protocol of Yared²⁰. Preparation with larger files may have yielded a higher degree of cleanliness. However, the apical size that must be obtained to ensure optimal cleanliness remains to be determined^{2,29}.

As previously stated, it has been reported that cervical preflaring improves cleaning ability²⁴. However, cervical preflaring may not be the only factor which determines apical cleaning capacity; for optimal results, it may be necessary to use the full conventional rotary system sequence, exactly as the manufacturer recommends, or even a single file, since that is what they are designed for⁸. It may not always be possible to clean the root canal efficiently, even when using a rotary system in full sequence, and at such times it may be necessary to employ hybrid instrumentation (rotary/manual)²⁵. On the other hand, oval-shaped canal instrumentation tends to leave unprepared surfaces with remaining debris, demonstrating the influence of the original root canal shape on the debridement quality, regardless of the preparation technique used^{8,19,26}.

Instrument movement is as important as the preparation method. In this study, the ProTaper F2 was used with a rotary motion, in accordance with the manufacturer's instruc-

tions and its design. Other studies, on the other hand, have employed clockwise and counterclockwise movement or a reciprocating movement^{9,29}. Reciproc and WaveOne nickel-titanium files are designed to allow complete preparation and cleaning of root canals with only one instrument. They were designed to be used with counterclockwise movements only, while a reciprocation working motion consists of both counterclockwise (when the instrument cuts) and clockwise movements (when the instrument is released); the angle of the counterclockwise cutting direction is greater than the angle of the reverse direction^{5,20}. Thus, considering that the ProTaper file was initially designed to cut in a clockwise motion, it may be relevant to investigate whether instrument movement variation can influence cleaning efficiency, as well as the number of files used.

Another point is the use of irrigant to complement traditional methods of cleaning and shaping^{1,11,23}. The irrigant requires time to play its role, so the fastest preparation does not always mean the most effective cleaning. Thus, cleanliness does not just rely on the method of preparation. The properties of each type of irrigant should also be investigated, together with the effects of concentration and technique when using a single file³⁰. It is possible that passive ultrasonic irrigation may improve the cleaning ability of single-file instrumentation techniques, as previously reported^{21,27}.

In this study, we approximated clinical conditions by using extracted human teeth selected in a standardized manner. Nevertheless, the findings should be extrapolated to a clinical situation with care. As stated, traditional cleaning and shaping methods may require more time, and adequate root canal preparation must be achieved, regardless of the technique and number of instruments used.

The results of this study suggest that cleaning capability improves when root canal preparation using ProTaper F2 is complemented by prior cervical enlargement. When other instruments were used in the presence or absence of cervical third preparation, no

significant difference was observed in degree of cleanliness.

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