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Research Article

Comparison of Root Canal Cleaning Ability of Rotary and Reciprocating File Techniques: A SEM Study

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Abstract

The purpose of this *in vitro* study, using SEM, was to compare the debridement of the root canal following rotary (full sequence ProTaper till F2) versus reciprocating instrumentation (Wave One and single F2 in reciprocating movement). Having standardized the preparation procedure for all treatment groups, the presence of superficial debris and smear layer were evaluated and graded as well in the coronal, middle and the apical regions of the root canal walls.

INTRODUCTION

Single file systems and reciprocating motion kinematics are the two recently proposed concepts in modern endodontics [1]. Single-file technique is cost effective and convenient as a single file is required to shape the root canal completely thus requiring a shorter period of time to prepare even curved canals [1]. Reciprocating kinematics was initially proposed with a single F2 ProTaper instrument (Dentsply Maillefer) to simplify and shorten the root canal shaping procedure and to reduce instrument fatigue [1,2].

Convenience, cost effectiveness and reduced time during root canal instrumentation are important factors to be considered but the prime objective of root canal instrumentation is to remove debris and smear layer from the root canal system and to facilitate disinfection by irrigants and medicaments [3]. The evaluation of single file reciprocating instruments in terms of their canal cleaning ability is essential as the deficient mechanical preparation could offer an opportunity for remaining microorganisms to recolonize the filled canal space, resulting in endodontic failure [4].

The ProTaper Universal rotary system is widely used multi file system to prepare root canals through the world [5-7]. Previous studies on the cleaning ability of ProTaper universal rotary system have conflicting outcomes [2,8- 10]. In 2008, a new preparation technique with only one ProTaper F2 instrument in a reciprocating motion was proposed and has shown similar shaping outcomes and adequate cleaning in round canals [11-14]. WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) is a relatively new single file Ni-Ti system and is designed to work in a reciprocating manner [15-17].

MATERIALS AND METHODS

The study was approved by the institute's ethical committee and was performed on recently extracted, single rooted human mandibular premolars with fully developed roots and extracted for periodontal reasons. Each sample was subjected to mesiodistal and buccolingual radiographs to verify the presence of a single straight canal with an intact pulp chamber. Sixty roots with comparable canal width and outline were finally selected and stored in purified filtered water throughout the study [12]. The study was performed on oval canals and so only those roots having buccolingual width approximately twice the mesiodistal widths were selected. All teeth with previous root canal treatment, incomplete root formation, external or internal root resorption, aberrant anatomy or roots smaller than 15 mm were discarded. Also, all roots were observed in a stereomicroscope under 12x magnification (Zeiss Stemi SV6, Jena, Germany) to exclude any external defects or cracks and were discarded if any of these characteristics were found.

All selected teeth were decoronated perpendicular to long axis of tooth by using a diamond coated bur with water cooling, leaving roots approximately 16 mm in length, to ensure a straight line access and provide a reference plane. After the access cavity preparation, canal patency was established with size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland). The working length was established by advancing the size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland) into the canal until just visible at the apex under a surgical microscope at 4x magnification and then subtracting 1 mm from this measurement. To simulate clinical conditions, apices were sealed with hot glue, and to prevent the glue from entering the canal, a size

10 K-file was inserted before the apex was sealed. Thereafter, they were embedded in autopolymerizing acrylic resin and periodontal ligament simulation was done using hydrophilic vinyl polysiloxane impression material. Now they were randomly distributed into three experimental groups of twenty teeth each.

Root canal preparation

Group 1 (20 teeth): These teeth were prepared with ProTaper rotary system (Dentsply Maillefer). Canals were prepared in a crown-down fashion with the aid of an X-SMART electric motor with torque control (Dentsply Maillefer) at 300 rpm. The ProTaper Shaping SX, S1, and S2 and finishing F1 and F2 files were sequentially used with a continuous in and- out movement till working length was reached. Torque and other parameters for each file were set as per the manufacturer's recommendation.

Group 2 (20 teeth): the entire canal preparation in this group was completed with a ProTaper F2 file (Dentsply Maillefer) used in a reciprocating motion. The ATR Tecnika endomotor (Dentsply Tulsa Dental, Oklahoma City, OK) allows programming for reciprocating movement at four-tenths of a circle CW (clockwise) and two-tenths of a circle CCW (counterclockwise). The F2 file was driven at 400 rpm with a 16:1 reduction ratio contrangle handpiece. During preparation the instrument was used with slow pecking motions and light apical pressure. If some resistance was felt that would have required more apical pressure, the instrument was removed, and the flutes were cleaned. This was repeated until working length was reached.

Group 3 (20 teeth): A primary reciprocating WaveOne (Dentsply Maillefer, Ballaigues, Switzerland] file having a size 25 and a taper of 0.08 was used in a reciprocating, slow in and-out pecking motion until reaching the full WL, according to the manufacturer's instructions. The dedicated reciprocating motor (Dentsply Maillefer, Ballaigues, Switzerland) of the WaveOne file was used with the manufacturer configuration setup.

Canals in all groups were irrigated using 2.5 ml of a 3 % NaOCl solution after each instrumentation, using a hypodermic 2.5-mL plastic syringe and a 27- gauge needle inserted deeply at 1 mm from the working length. About 15 ml of NaOCl was used to prepare each canal irrespective of the number of instruments used. For final rinsing of the canals, 5 mL each of EDTA, NaOCl and distilled water were used in sequence and then dried with absorbent points. A single experienced operator performed all the procedures. In each of these three test groups, one set of instruments was used for the preparation of four root canals.

Preparation of specimens for scanning electron microscopy

Longitudinal grooves were made on the buccolingual surfaces on each root by using a silicon carbide disk and were then split into halves using a chisel. During splitting the corresponding gutta-percha cone was placed in the root canal to protect it from getting contaminated by the debris during the splitting process. One of the halves was then randomly chosen and prepared to be examined under a scanning electron microscope (Carl Zeiss EVO MA15; Oberkochen, Germany) at 200 X for debris and at 1000 X for smear layer evaluation.

After scanning and observing each region with the microscope, an image of the most representative area of that third was taken. In a blinded manner, 2 investigators other than those who prepared the canals and performed scanning electron microscopy, scored smear layer and debris on the surface of the root canal walls at the coronal, middle, and apical portions [18].

When both examiners independently agreed on a score, it was recorded. In case of disagreement, they discussed the sample and its scoring, and an agreed score was reached. Kruskal–Wallis test and Mann–Whitney U test were used for data analysis at P = .05.

RESULTS

Mean and standard deviation of debris and smear layer at different levels is summarized in Table 1 and 2 respectively.

Only significant difference in remaining debris was found at apical third level wherein less debris was found in full sequence ProTaper and single F2 ProTaper in reciprocating motion groups than wave one group (p<0.050). At the same level, full sequence ProTaper and single F2 ProTaper in reciprocating motion did not

Table 1: Summarization statistics for Debris at coronal, middle and apical third.

Desired location of root canal	Instrument used	Mean ± SD
Coronal	Protaper	1.70 ± 0.73
	F2 Protaper	2.10 ± 0.718
	Waveone	2.05 ± 0.759
Kruskal Wallis	**p- value – 0.178; Not Significant**	
Middle	Protaper	2.10 ± 0.641
	F2 Protaper	2.55 ± 0.826
	Waveone	2.35 ± 0.745
Kruskal Wallis	**p- value – 0.158; Not Significant**	
Apical	Protaper	2.40 ± 0.681
	F2 Protaper	2.70 ± 0.733
	Waveone	3.40 ± 0.754
	p- value – 0.001; Significant	
Mann Whitney	**Protaper vs. F2 Protaper [p=0.221] Protaper vs. Waveone [P=0.001] F2 Protaper vs. Waveone [P=0.007]**	

Table 2: Summarization statistics for smear layer at coronal, middle and apical third.

Desired location of root canal	Instrument used	Mean ± SD
Coronal	Protaper	2.75 ± 1.07
	F2 Protaper	2.60 ± 0.821
	Waveone	2.75 ± 0.967
Kruskal Wallis	**p- value – 0.891; Not Significant**	
Middle	Protaper	3.00 ± 0.795
	F2 Protaper	3.15 ± 0.889
	Waveone	3.20 ± 1.07
Kruskal Wallis	**p- value – 0. 830; Not Significant**	
Apical	Protaper	3.40 ± 0.995
	F2 Protaper	3.50 ± 0.889
	Waveone	3.70 ± 1.081
	p- value – 0. 635; Significant	

show any significant difference in debris removal. No significant difference was found at any level in terms of smear layer produced by different instrumentation techniques.

DISCUSSION

The three instrumentation systems used in this study were selected because they share the same tip size and taper [9,15]. Similar volume of irrigant was delivered in all samples irrespective of single file system or multiple file system used [16]. The reason to choose oval shaped canals was simple as such canals pose real difficulty in cleaning and shaping [17].

As in previous studies, none of the instrumentation systems tested was able to completely clean the canal at any level [2-4,9,10]. The amount of remaining debris decreased from coronal to apical third and this may be due to the more complex anatomy in apical third or to the better access of irrigant in coronal and middle areas of root canal [14,16,17]. The vapour lock phenomenon is another contributory factor [19].

The overall debridement efficacy of the ProTaper Universal was significantly better than single file F2 ProTaper technique and WaveOne ($P < 0.001$). In the apical third region, rotary full sequence ProTaper instruments cleaned better than WaveOne and single F2 in reciprocating movement ($p = 0.002$). Less debris in the apical area corresponds to less microorganisms and this makes rotary ProTaper full sequence a preferred technique to prepare oval shaped canals in the apical third region. De-Deus et al displayed suboptimal debridement quality produced by the single file F2 ProTaper technique in oval shaped canals [14]. Robinson et al., utilized three dimensional microcomputed tomography and found more densely packed debris in canals prepared by WaveOne as compared to those prepared by full sequence ProTaper group [2]. In another study, more debris was found in samples treated with ProTaper than with WaveOne [8]. Also, the results were significantly different at coronal and middle third and not at apical third level [8]. This was attributed to more debris created by ProTaper at the outset [8]. The irrigation protocol used by Burklein et al differs from the present study and this could have resulted in different results [8].

The present result shows that multifile group (continuous full sequence ProTaper) enabled better debris removal than single file groups (Table 2). With multifile technique, the advantage is that the canals are irrigated more frequently and thus debris will have less opportunity to accumulate in a tooth that is more frequently irrigated despite the total end volume of irrigant being similar for multifile and single file groups [8]. In single file systems, a single reciprocating file works through its entire length and as it is shaping the apical two- third of the canal, the coronal shaping is still going on [8]. This makes the file to work against itself in extracting debris from the tooth. However in multifile ProTaper system, the finishing files engage mostly in the apical area of the canal and have reduced contact with the coronal dentine thus enabling debris to exit through the coronal recess created between instrument and root canal wall [8]. Coronal preflaring with reciprocating systems is expected to have more acceptable outcome.

The insignificant difference between full sequence ProTaper and single F2 ProTaper at all levels evidence the minimal bearing of motion kinematics on canal debridement. Single F2 ProTaper and WaveOne groups share similar motion kinematics and significant difference among them was found only in the apical third area and not in the middle and coronal third area. The radial land feature in the cross section design of WaveOne in the tip region might be associated with the poor debridement quality of WaveOne file in the apical third area [8,10]. There is some evidence that NiTi instruments with active cutting blades show better canal cleanliness than instruments with radial lands [8]. Radial lands tend to burnish the cut dentine into the root canal wall, whereas instruments with positive cutting angles seem to cut and remove the dentine chips [8].

The evaluated instruments do not differ significantly in terms of smear layer removing ability ($p > 0.05$). Many previous investigations have resulted in similar results [3,8,9,16]. All the instrument systems used in this study resulted in 8 % taper leading to easy flow of irrigants in and out of the canal. The smear layer removal seems to be a factor more related to the delivery of irrigants in the canal and less to the type of instruments used to prepare the root canal [21]. Strict irrigation protocol was followed during root canal shaping and EDTA and NaOCl was used at the end to detach smear layer.

The mode of irrigation used in this study could be a limitation as other irrigation modes like EndoVac (Discus Dental, Culver City, CA) and EndoActivator (Dentsply Tulsa Dental Specialties, Tulsa, OK) have superior debris and smear layer removing ability [8,20,21]. These irrigation aids could be particularly helpful with single file systems because of reduced irrigation time available with use of such systems.

The SEM methodology used in this study enabled only surface to be examined and provides minimal knowledge about the depth of the debris [22]. Specimen preparation induces artifacts and there are some practical restraints in grading the root canal when a scoring system is used [22]. The scores of two investigators differ only on five occasions and thus we speculated that sufficiently representative view of the debridement of the root canal was achieved in the present study. However, future studies using MicroCT, debris can be quantified three dimensionally in a nondestructive and noninvasive manner [2].

HIGHLIGHTS

1. The cleaning efficiency of rotary and reciprocating files were examined in oval shaped canals through debris and smear layer scores using SEM.

2. Only significant difference in remaining debris was found at apical third level wherein less debris was found in full sequence ProTaper (till F2) and single F2 ProTaper in reciprocating motion groups than primary wave one group.

3. No significant difference was found at any level in terms of smear layer produced by different instrumentation techniques.

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