Evaluation of Cleaning Efficacy of S-One and WaveOne File Systems Using Scanning Electron Microscopy Analysis: An In Vitro Study

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Abstract

Aim: The aim of this study is to compare the canal cleaning ability of S-One file (AF BLUE) system with WaveOne Gold single file system, using scanning electron microscopy (SEM).

Materials and methods: In the present study, 40 freshly extracted permanent mandibular premolars with a single-root canal and straight roots were selected. The teeth were randomly divided into three groups. The canals were prepared by crown-down technique. Buccolingual sectioning of the samples were done followed by SEM evaluation. Data were statistically analyzed using Kruskal–Wallis test. The statistical significance level was set at p value <0.05.

Results: The analysis of the results demonstrated that WaveOne presented higher cleaning capacity of root canals with a statistically significant difference, when compared to S-One file system (p value < 0.05). Both the file systems showed significant cleaning efficacy in the coronal and middle-thirds of the root canals when compared to the apical thirds. Also, the WaveOne showed better results than S-One (AF BLUE), and the results were statistically significant.

Conclusion: With the limitation of the study, the cleaning ability of rotary file system is high in coronal and middle-third followed by apical third. In this study, the WaveOne showed better results than S-One (AF BLUE), and the results were statistically significant.

Clinical significance: The aggressive cutting of dentin during canal preparation is less in WaveOne file than S-One file system. The cleaning efficiency is good in reciprocating file system (WaveOne) than continuous rotary file system (S-One).

Keywords: Biomechanical preparation, Nickel titanium, Rotary files, Scanning electron microscopy.

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Introduction

Endodontic therapy is directed toward one major aim that is to cure or prevent periradicular periodontitis that is obtained by effective disinfection and subsequent sealing of the root canal system. Shaping and cleaning is a part of root canal treatment that helps in adequate disinfection of the canals. The primary objectives of shaping and cleaning are to remove the infected soft and hard tissues to give the disinfecting irrigants access to the apical canal space, create space for delivery of irrigants and obturating materials, and to retain the integrity of the radicular structures..

Many instruments, devices, and instrumentation techniques have been recommended, but only few seem to be capable of consistently achieving these primary objectives of root canal preparation.

The stainless steel (SS) hand files have been the principal endodontic instruments to prepare the root canals, but it is shown to produce undesirable results, especially when used in curved canals. The excessive stiffness of the larger file sizes increases the incidence of canal aberrations, such as zips, elbows, ledges, and perforations. Such problems have resulted in a search for new materials for fabricating endodontic instruments.

Civjan was one of the first investigators to introduce nickel–titanium (Ni–Ti) alloy for use in endodontics in 1975. Later, Walia in 1988 evaluated the physical properties of some of the first Ni–Ti files that were machined from orthodontic wires. Ni–Ti instruments were found to have a wider range of elastic deformation and greater flexibility than the same size SS instruments. Currently, canal preparation is less tiring and more standardized by using Ni–Ti instruments and by the introduction of high torque rotary handpieces. Rotary Ni–Ti instruments are able to maintain the canal shape even in severely curved canals and the preparation with these instruments is faster than hand preparation.

Several developments have been made by the manufacturers to improve the flexibility and resistance to fracture of Ni–Ti rotary endodontic instruments. These developments include changing the taper over the length of the cutting blade, modifying the instrument’s cross-sectional design, and enhancement of the manufacturing process or the use of newer alloys that provide improved mechanical properties. This trend has led to introduction...
of a variety of Ni–Ti instruments that are available in the market, with varying properties and designs.

Nowadays, Ni–Ti rotary file systems made of various alloys (conventional, R-phase, M-Wire, and GOLD Wire Ni–Ti) and kinematics (continuous rotation, reciprocation, and adaptive motion) are used.10,11 Besides their advantages, Ni–Ti alloys also have certain disadvantages, such as high fracture incidence due to cyclic fatigue. To prevent these fractures, single-file reciprocation systems are recommended.12

WaveOne single-file system (Dentsply Maillefer) is a Ni–Ti rotary file developed in 2011 by Dr. Clifford Ruddle (US) et al. This system is intended for use with a special reciprocating file motion. WaveOne was recently modified to WaveOne GOLD (WOG, Dentsply Maillefer) and is manufactured using a new DENTSPLY proprietary thermal process, producing a super-elastic Ni–Ti file.13 The gold process is distinctive gold finish and improves its strength and flexibility far in excess of its predecessor.14 S-One (AF BLUE) by Shanghai Fanta Dental Materials Co., LTD, is a new single-file system that is used in rotation motion and is manufactured from R-phase wire. It has greater resistance to cyclic fatigue and has more efficient cutting cross-section design. It is available in sizes 0.04/20, 0.04/25, 0.04/35, 0.06/20, 0.06/25, and 0.06/35 (taper/file size).15

The aim of this study is to compare the canal cleaning ability of S-One file (AF BLUE) system with WaveOne Gold single file system using scanning electron microscopy (SEM).

**Materials and Methods**

The study was conducted in the Department of Conservative Dentistry and Endodontics, Ragas Dental College, Chennai. In the present study, 40 freshly extracted permanent mandibular premolars with a single root canal and straight roots were selected. The teeth were stored in 1% sodium hypochlorite (NaOCl) for 3 days to eliminate organic debris. All the remaining calculus and soft-tissue remnants were removed from the root surfaces using ultrasonic scalers and stored in sterile saline solution at room temperature. Teeth with visible root caries, double canals, fractures, calcification, and internal resorption are excluded from the study.

The teeth were randomly divided into three groups.

Group I: S-One AF Blue; Group II: WaveOne gold; and a control group (n = 10) had noninstrumented teeth.

Standardized access cavities were prepared in each of the samples using round bur and/or endo access bur with a high-speed aerator and water spray. The root canals were negotiated using a 10K size file, and a glide path was prepared using 15K size file. By inserting a #10 size K-file (brand name), root canal patency was confirmed. Subsequently, the working length (WL) was recorded preoperatively by subtracting 1 mm from the length of the #10 size K-file when tip visualized at the apical foramen and confirmed with radiographs.

The samples were then randomly divided into the following groups depending on the file system used.

- **Group I (n = 15)** S-One file (AF BLUE)

The samples in this group were instrumented with primary file S-One 25(0.06 taper) (RC, VDW, Munich, Germany) using X Smart plus endodontic motor (Dentsply Maillefer, Switzerland), according to the manufacturer’s recommendations.

- **Group II (n = 15)** WaveOne Gold (WOG) (Dentsply Maillefer, Tulsa dental)

The samples in this group were instrumented with primary file WOG 25 (0.07 taper) using x-smart plus endodontic motor (Dentsply Maillefer, Switzerland), according to the manufacturer’s recommendations.

- **Group III (n = 10)** Control group: the samples in this group were left uninstrumented.

Both the file systems were used in the crown-down technique. All the canals were prepared by the same operator. Each instrument was used for four samples after it was discarded. After each file instrumentation, 3 mL of 3.0% sodium hypochlorite (NaOCl) was used for intracanal irrigation followed by a 1-minute rinse with 17% EDTA. After a complete cleaning shaping saline was used as a final rinse. The teeth were dried with paper points. All samples were decoronated and sectioned buccolingually for evaluation. Later, the samples were gold sputtered and examined under SEM to determine canal cleanliness. The samples were analyzed with the SEM at 30.0 kV and 700x magnification in the coronal, middle, and apical thirds of the canals.

Debris was defined as dentin chips, pulp remnants, and particles loosely attached to the root canal wall.16

The SEM images were analyzed using the following 5 score index (Hulsmann 1997):17

- **Score 1:** Clean root canal wall, only a few small debris particles;
- **Score 2:** Few agglomerations of debris;
- **Score 3:** Many agglomerations of debris covering <50% of the root canal wall;
- **Score 4:** More than 50% of the root canal wall covered by debris; and
- **Score 5:** Complete or nearly complete root canal wall covered by debris.

The debris score of all the samples was analyzed using Mann–Whitney U test.

**Results**

Comparison of Root Canal Cleaning Ability of ProTaper NEXT and WaveOne Rotary file systems: an SEM study.

The results revealed that the mean score for WaveOne was 1.4, for S-One was 2.9, and for the control group was 4.9.

Thus, on analyzing the results, it was demonstrated that WaveOne presented higher cleaning capacity of root canals with a statistically significant difference when compared to S-One file system (p value < 0.05) (Table 1). Both the rotary file systems showed highest cleaning efficacy in the coronal third followed by middle thirds with maximum debris remaining in the apical thirds of the root canals (Tables 2 and 3).

**Discussion**

Clinical success of root canal treatment depends on several factors, such as accurate diagnosis, locating the canals, biomechanical cleaning, type of restoration, and root canal filling material. Biomechanical preparation is one of the most important steps of primary root canal treatment that includes mechanical instrumentation followed by chemical irrigation. It is mainly aimed at the debridement of the canal that includes removal of smear layer, debris that is after all directed toward the elimination of microorganisms from the root canal system.18
Endodontic instrumentation has improved over the past few decades with the introduction of various rotary file systems with refined metallurgy, variations in design, and taper and innovative instrumentation techniques. Clinicians are facing problem of cross contamination with the use of Ni–Ti rotary systems involving series of files.19 To overcome this problem, various newer single-file systems were introduced.

In the current study, the canal cleaning ability of S-One file (AF BLUE) system with WaveOne Gold single file system was compared using SEM. S-One file has a variable cross-section in one file. It has minimum radial contact to ensure better cutting. The variable pitch ensures efficient debris transport and reduces the screwing effect.15 The WaveOne system, which is a single file reciprocating system with unequal clockwise/counter clockwise motion, has been claimed to be four times safer and almost three times faster than when using multiple rotary files to achieve the same final shape.20 The WaveOne 40/08 file, which has been used in the present study, has a fixed taper of 8% from D1 to D3, whereas from D4 to D16, it has a unique progressively decreasing percentage tapered design that serves to improve flexibility and conserves remaining dentin in the coronal two-thirds of the finished preparation. In addition, it has a reverse helix structure with two distinct cross-sections along their active portions. It also has a non-cutting modified guiding tip, which enables it to safely progress through tortuous canals ensuring safety and efficiency.21

In the present study, the cleaning efficacy of WaveOne (mean debris score = 1.4) was found to be superior to S-One (AF BLUE) (mean debris score = 2.9) and control group (mean debris score = 4.9), p value < 0.01 (Table 1). Similar studies with WaveOne files were conducted by Berutti et al., where WaveOne produced better debris removal than other file systems, especially at the coronal third of the root canals.22

Malentacca and Lalli observed that Ni–Ti instruments were significantly safer when used with a reciprocating movement than with continuous rotation. In accordance with this, it has been found that the reciprocating motion leads to a more centered preparation when compared to the continuous rotating motion.23 The continuous rotary motion results in an increased enlargement on the external side of the canal, especially in the apical third, leaving the inner curvature relatively untouched which thus concludes that reciprocating motion results in the superior cleaning efficacy.24

Both the file systems showed highest cleaning efficacy in the coronal thirds, followed by the middle-thirds, and apical thirds (Figs 1 and 2), (Tables 2 and 3), and the control group showed high debris score in coronal, middle, and apical third (Fig. 3 and Table 4). The coronal canals with relatively larger volume would get

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**Table 1:** The scoring chart of WaveOne gold file system

| Portion of root | Score 1 | Score 2 | Score 3 | Score 4 | Score 5 |
|-----------------|---------|---------|---------|---------|---------|
| Coronal         | 12      | 3       | 0       | 0       | 0       |
| Middle          | 10      | 5       | 0       | 0       | 0       |
| Apical          | 2       | 12      | 1       | 0       | 0       |

**Table 2:** The scoring chart of S-One file system

| Portion of root | Score 1 | Score 2 | Score 3 | Score 4 | Score 5 |
|-----------------|---------|---------|---------|---------|---------|
| Coronal         | 6       | 9       | 0       | 0       | 0       |
| Middle          | 1       | 6       | 8       | 0       | 0       |
| Apical          | 0       | 3       | 10      | 2       | 0       |

**Table 3:** The scoring chart of control group

| Portion of root | Score 1 | Score 2 | Score 3 | Score 4 | Score 5 |
|-----------------|---------|---------|---------|---------|---------|
| Coronal         | 0       | 0       | 0       | 1       | 14      |
| Middle          | 0       | 0       | 0       | 0       | 15      |
| Apical          | 0       | 0       | 0       | 0       | 15      |

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Figs 1A to C: Scanning electron microscopy (SEM) images showing root surfaces after instrumentation by WaveOne File system: (A) Coronal third of root canal; (B) Middle third; (C) Apical third.
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a sufficient mechanical and chemical flushing that consequently results in better disinfection compared to other portions of canal. However, compared to coronal and middle canals, apical thirds in the root canals exhibited maximum debris. The increase in debris score in the apical third can be due to increased canal ramification and complex morphology at the apical third of the canal.25,26

Also, the cleaning ability of all the instruments in the apical third of the canal was less than middle and coronal third regardless of instrument used. This could be due to use of torque control hand piece reduces the cutting efficiency of instrument and progression of the file into apical third becomes more difficult.26

A number of methodologies have been used to evaluate endodontic instrumentation, including plastic models, histological sections, scanning electron microscopic studies, serial sectioning, radiographic comparisons, and silicon impression of instrumented canals.27–31 An SEM was used in this study to evaluate the results. With the SEM, the surfaces of the debrided root canals could be examined at high magnifications and with excellent depth of focus. Each sample was gold sputtered before SEM analysis in order to improve the conductivity of the sample surface. That is, if the surface was nonconducting, the electron charge will bombard with the sample, and the accumulating charge will create charging effect and the images produced would be blurred.32 Remaining debris and microbes on the root canal walls could then be photographed and assessed.

**Conclusion**

It may be concluded that the innovative rotary file systems show significant cleaning efficacy in the coronal and middle thirds of the root canals when compared to the apical thirds. Also, the WaveOne showed better results than S-One (AF BLUE), and the results were statistically significant. However, further studies need to be conducted to corroborate the findings of this study.

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