

## Comparative Evaluation of Cleaning Efficacy of Self-adjusting File and WaveOne File: An *in vitro* Scanning Electron Microscopic Study

### Abstract

**Aim:** This study aims to compare the cleaning efficacy of root canal walls using two rotary single file systems: self-adjusting file (SAF) and WaveOne (WO). **Materials and Methods:** Forty extracted human premolars with similar range of canal curvature were selected, decoronated, working length determined and roots were divided into two groups of 20 samples each: Group I - SAF and Group II - WO. All root canals were irrigated with 3% sodium hypochlorite (NaOCl) and 17% ethylenediaminetetraacetic acid (EDTA). The roots were sectioned longitudinally and subjected to scanning electron microscopic examination. The amount of debris and smear layer was evaluated using five score index at coronal, middle and apical third levels. Statistical analysis was performed using the Chi-square test and significance was set at a  $P < 0.05$ . **Results:** Statistically significant difference was observed between the groups in cleaning the apical third. Group I (SAF) showed better canal cleanliness compared to Group II (WO) in the apical third. **Conclusion:** Within the limitations of this study, SAF in combination with 3% NaOCl and 17% EDTA irrigating solution had significantly better cleaning efficacy in the apical third of root canals when compared to WO rotary file system.

**Keywords:** *Ethylenediaminetetraacetic acid, self-adjusting file, scanning electron microscopic, smear layer, sodium hypochlorite, WaveOne file*

### Introduction

Canal shaping and cleaning is a vital part of endodontic treatment. Endodontic shaping instruments has evolved over time to maximize debridement and decrease procedural errors.<sup>[1]</sup> Despite the numerous advantages of nickel–titanium (NiTi) rotary instruments, complete debridement and removal of smear layer remains a demanding task. Recent developments in alloys, improved mechanics and novel ideologies have lead to increased efficiency of NiTi instruments. However, many currently available rotary systems lack the ability to achieve complete cleanliness especially in curved and oval canals as the design does not address the natural three dimensional (3D) shape of many canals.<sup>[2,3]</sup>

The combination of novel metallurgy and reciprocating motion has led to the development of “single file” systems. self-adjusting file (SAF) (ReDent-Nova), the 3D canal adaptation system with simultaneous irrigation promotes a uniform

removal of dentin when used in a transline motion.<sup>[4]</sup> WaveOne (WO) files (Dentsply Maillefer Ballaigues, Switzerland) is a prepackaged, presterilized, single-use system indicated to shape the root canal using reciprocal motion.<sup>[5]</sup> The M-wire technology created by thermal-treatment process has given the added advantage of increased flexibility and improved resistance to cyclic fatigue.<sup>[6]</sup>

Mechanical instrumentation alone does not result in a microbe free root canal system, due to anatomical complexities in the root canal.<sup>[7]</sup> Thus, irrigants are essential to ensure bacterial minimization and elimination of organic tissue remnants.<sup>[8,9]</sup> The dual combination of sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA) has been the most common irrigation regiments used for endodontic treatment. NaOCl, with its antibacterial and dissolving effects on the necrotic tissues, is the most popular root canal irrigant.<sup>[10]</sup> But, it has its own limitations of inability in smear layer removal. The chelating action of EDTA

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**DOI:** 10.4103/ccd.ccd\_160\_19

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**How to cite this article:** Bakthavatchalam B, Ranjani MS, Amudhalakshmi K. Comparative evaluation of cleaning efficacy of self-adjusting file and waveone file: An *in vitro* scanning electron microscopic study. *Contemp Clin Dent* 2019;10:542-7.

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removes smear layer and enables penetration of intra canal medicaments and complete adaptation of obturating materials in root canal surface.

The purpose of this study is to compare the cleaning efficacy of two different single file systems; SAF and WO System using 3% NaOCl and 17% EDTA as irrigants.

## Materials and Methods

Forty recently extracted, intact noncarious mandibular premolars were selected, disinfected with thymol and stored in normal saline. Each tooth was radiographed in buccolingual and mesiodistal projections to evaluate the shape of the root canal and to detect any obstruction. The root canal curvature was determined by Schneider's method. The tooth with straight root canal <math><5^\circ</math> angle were included in this study. All teeth were decoronated using water cooled low speed diamond disc leaving 13 mm long roots. The canal diameter was standardized by selecting the roots fitting #15 K file at the apex. The root canals were negotiated with K file #10 to maintain apical patency and working length was determined 1 mm short of the apex. All canals were enlarged up to 25 size K file by manual instrumentation and saline irrigation. Apical foramen of all selected teeth were sealed with casting wax, numbered, labeled, and randomly divided into two equal experimental groups of twenty samples each.

### Group 1 (self-adjusting file)

SAF was used according to manufacturer's instructions. The irrigant flow rate of 5 ml/min was set in the VATEA irrigation device and the file was gently inserted in the root canal and operated by in-and-out vibrations. The following irrigation protocol was followed: 3% NaOCl for 3 min and saline for 2 min followed by 17% EDTA for 1 min.

### Group 2 (WaveOne)

WO file was used according to manufacturer's instruction. The X-smart plus endomotor was used in "WaveOne" mode. Primary WO file (#0.25.08) was used for cleaning and shaping. The file was operated by inward pecking motion with short 2–3 mm amplitude strokes passively up to the determined working length with following the same irrigation protocol, i.e., 3% NaOCl for 3 min, saline for 2 min, and finally 17% EDTA for 1 min, using 30-gauge closed end needle with plastic syringe 1 mm short of working length.

All the root canals were then irrigated with 5 ml saline as the final rinse. The specimens were dried with absorbent paper points and allowed to dry at room temperature for 24 h. Deep grooves were cut using a diamond disc on each root on the buccal and lingual surfaces without perforating the root canal. The roots were longitudinally split into two halves along the groove with chisel. One half of each tooth was selected and prepared for scanning electron microscopic (SEM)

examination (Hitachi E 1010). After assembly on coded stubs, the specimens were placed in a vacuum chamber and sputter-coated with a 300 Å gold layer and subjected to SEM analysis. The dentinal wall of the cervical, middle and apical thirds of each prepared specimens were observed at  $\times 200$  and  $\times 1000$  for the presence of debris and smear layer, respectively.

### Scoring criteria

Hulsmann scores were used for evaluation of debris and smear layer.<sup>[11]</sup>

#### Debris score

- Score 1: Clean root canal wall and only a few small debris particles
- Score 2: A few small agglomerations of debris
- Score 3: Many agglomerations of debris covering <math><50\%</math> of the root canal wall
- Score 4: More than 50% of the root canal walls were covered with debris
- Score 5: Complete or nearly complete root canal wall coverage with debris.

#### Smear layer score

- Score 1: No smear layer and all dentinal tubules were open
- Score 2: A small amount of smear layer, and some dentinal tubules were open
- Score 3: Homogeneous smear layer covering the root canal wall, and only a few dentinal tubules open
- Score 4: Complete root canal wall covered by a homogeneous smear layer and no open dentinal tubules were observed
- Score 5: Heavy, homogeneous smear layer covering the complete root canal wall.

Scores 1 and 2 represent "clean canal wall." Scores 3–5 represent "presence of smear layer." Results were statistically analyzed by Chi-square test.

## Results

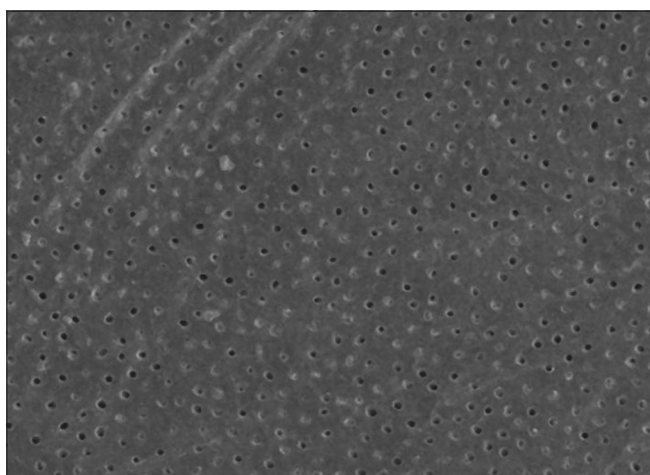
Tables 1 and 2 show the comparison of debris and smear scores respectively for each group at coronal, middle, and apical thirds. On comparing the debris score, Group 1 (SAF) and Group 2 (WO) resulted in 100% clean canals in coronal and middle third. In apical third, 100% of canals were debris free when instrumented with SAF [Figure 1] but WO resulted in only 35% canals free of debris [Figure 2] with statistically significant difference between the two systems  $P = 0.000$  [Table 1].

On comparing the smear layer scores, Group 1 (SAF) and Group 2 (WO) resulted in 100% clean canals with open dentinal tubules in coronal third and 90% clean canals in middle third. At apical third, SAF resulted in 65% of canals free of smear layer but WO was not effective in eliminating smear layer [Figures 3 and 4]. Statistically significant

**Table 1: Debris score for each group and summarization of statistics between two groups for debris**

Location	Groups	Scores					Total	Pearson $\chi^2$	P
		1	2	3	4	5			
Coronal	I (SAF)	19	1				20	1.111	0.292
	Percentage within the group	95	5				100		
	II (WO)	17	3				20		
	Percentage within the group	85	15				100		
Middle	I (SAF)	15	5				20	0.125	0.723
	Percentage within the group	75	25				100		
	II (WO)	14	6				20		
	Percentage within the group	70	30				100		
Apical	I (SAF)	13	7				20	26.000	0.000
	Percentage within the group	65	35				100		
	II (WO)		7	8	5		20		
	Percentage within the group		35	40	25		100		

SAF: Self-adjusting file; WO: WaveOne



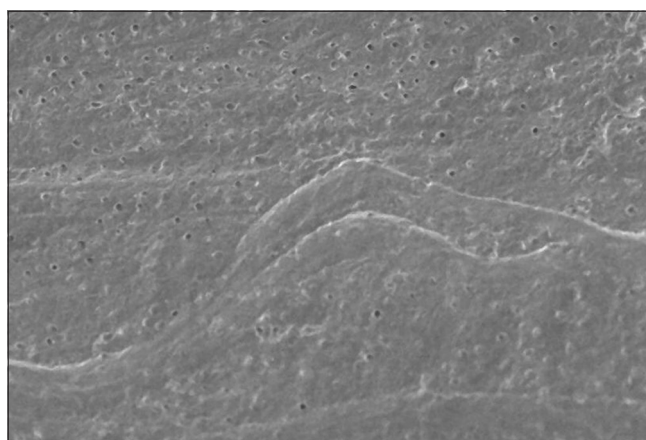
**Figure 1: Debris-free dentinal tubules at apical level with self-adjusting file at  $\times 200$**

difference was observed between the two systems in apical third  $P = 0.000$  [Table 2].

## Discussion

Ni-Ti rotary instruments were introduced to achieve the mechanical objectives of canal preparation. The currently available rotary Ni-Ti file systems are operated by continuous rotation, requiring multiple instruments for canal preparation. To overcome this drawback, advancement in canal preparation procedures was achieved with reciprocation and introduction of single file systems.

SAF has a hollow tube made from a thin NiTi lattice with a rough outer surface and an asymmetrically positioned tip located at the wall of the tube as opposed to solid central metal shaft with blades, flutes and symmetrically centered tips in currently used rotary file systems. The SAF system provides 3D shaping and cleaning of the canal as it is extremely flexible and compressible and adapts to the cross-sectional shape of the canal.<sup>[2,12]</sup> The kinematics in SAF is 5000 rpm, which results in 5000 vibrations/min with



**Figure 2: Debris-blocked dentinal tubules at apical level with WaveOne at  $\times 200$**

pecking motions. The SAF file is provided with VATEA irrigation pump allowing for flow of the irrigant through the hollow file and into the root canal. SAF does not cut dentin instead has gentle abrasive effect thereby maintains the integrity of radicular dentin, preserves the original shape of the canal and prevents generation of microcracks in dentin and eliminates the risk of vertical root fracture.<sup>[13]</sup> SAF undergoes mechanical failure in the form of tears in the lattice involving either a partial detachment of an arch or strut where the file is discarded or full detachment of an arch where it is easily washed out during SAF irrigation or ultrasonic-assisted irrigation.<sup>[14]</sup>

The WO system with M wire technology involves heat treatment at various temperatures that results in a phase shift which helps in maintaining the pseudoelastic state.<sup>[15]</sup> Moreover, the presence of nanocrystalline martensitic grains embedded in austenite matrix imparts greater flexibility and resistance to cyclic fatigue than traditional NiTi files.<sup>[16]</sup> The WO files have reverse cutting blades and modified convex triangular crosssection at the tip. The kinematics of WO files is 350 rpm. At 150° of counterclockwise rotation, the

file advances and engages to cut the dentine in the canal. It gets disengaged at 30° of clockwise rotation before excessive torsional stress is transferred onto the metal alloy thereby minimizing the risk of fracture.<sup>[17,18]</sup>

The role of irrigant is indispensable in complete debridement of root canals. Mechanical instrumentation of root canals results in formation of smear layer on the dentinal walls.<sup>[19]</sup> Retention or removal of smear layer remains a controversy. Smear layer itself may be infected and also prevents the penetration of irrigants and intracanal medicaments.<sup>[20]</sup> Moreover smear layer interferes with adhesion of root canal sealers and thereby affecting the success of endodontic treatment.<sup>[21]</sup> In teeth with infected root canals smear layer removal is very important where the success of root canal treatment depends on eradication of microorganisms and their byproducts.<sup>[22]</sup>

In this study, both systems were able to attain clean canals in coronal and middle third. This can be explained by the larger diameter of dentinal tubules in coronal regions exposed to increased volume of irrigants and thus making

debris and smear layer removal easier.<sup>[23]</sup> In the apical third, SAF resulted in better performance than WO with statistically significant difference between the two systems. The success of SAF can be attributed to the compressible hollow lattice design that allows for continuous flow of fresh and fully active irrigant throughout the procedure.<sup>[24]</sup> Metzger *et al.* explained that the mechanical scrubbing action with in and out vibration movement of the SAF system removed uniform dentin layer resulting in less amount of debris and this dentin powder gently gets flushed out by the flow of irrigant.<sup>[12,25]</sup> Similar results were reported by Jimna *et al.*, who reported that effective removal of smear layer in apical third of root could be achieved with SAF using 5% NaOCl and 17% EDTA.<sup>[26]</sup> de-Deus *et al.* and de Melo Ribeiro *et al.* reported successful debridement using SAF in oval shaped canals.<sup>[27,28]</sup> SAF has added advantage of the vibrating motion of the file's delicate mesh within the fluid, which is being continuously replaced.<sup>[29]</sup>

A conventional syringe irrigation with closed end needle was used with WO 1 mm short of working length with irrigant holding time of 1 min to avoid possible extrusion of the irrigant and to prevent the injury of periapical

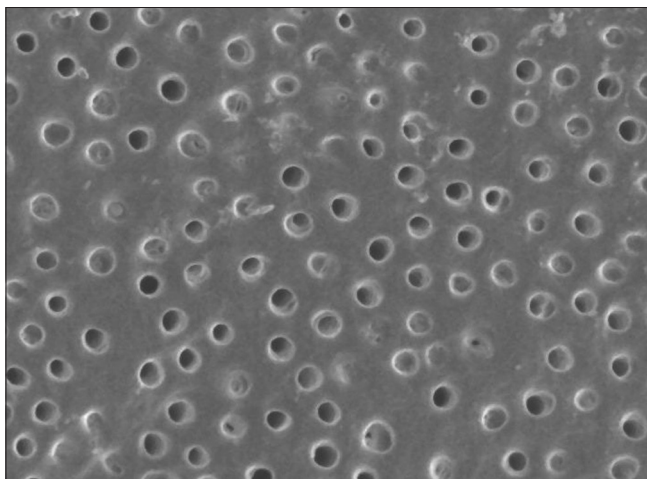


Figure 3: Smear-free open dentinal tubules at apical level with self-adjusting file at ×1000

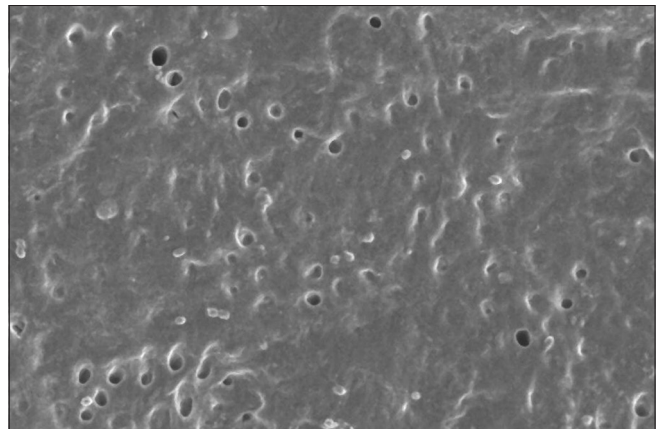


Figure 4: Smear layer-blocked dentinal tubules at apical level with WaveOne at ×1000

Table 2: Smear layer score for each group and summarization of statistics between two groups for smear layer

Location	Groups	Scores					Total	Pearson $\chi^2$	P
		1	2	3	4	5			
Coronal	I (SAF)	18	2				20	0.229	0.633
	Percentage within the group	90	10				100		
	II (WO)	17	3				20		
	Percentage within the group	85	15				100		
Middle	I (SAF)	15	3	2			20	0.177	0.915
	Percentage within the group	75	15	10			100		
	II (WO)	14	4	2			20		
	Percentage within the group	70	20	10			100		
Apical	I (SAF)	5	8	5	2		20	23.231	0.000
	Percentage within the group	25	40	25	10		100		
	II (WO)			5	11	4	20		
	Percentage within the group			25	55	20	100		

SAF: Self-adjusting file; WO: WaveOne

tissues. However, the use of newer irrigating systems such as sonics (endoactivator), ultrasonics (passive ultrasonic irrigation), and negative pressure irrigating tools (Endovac) along with WO could have generated different results. However, for those devices to be truly effective, an apical preparation to #40/0.04 or #40/0.06 is required.<sup>[30,31]</sup> Such preparations leads to unnecessary and excessive removal of sound dentin, especially in curved root canals.<sup>[32]</sup> However, cleaning efficacy cannot be completely attributed to the irrigation mechanism used. The reciprocating motion of WO file is found to induce greater debris accumulation and create a burnishing effect.<sup>[33,34]</sup> On the other hand, SAF has a gentle abrasive action and the resultant dentin powder gets flushed away by the flow of irrigant.<sup>[35]</sup> Thus, the tendency of WO files to generate more debris combined with vapor lock effect caused by close ended needle could be the possible reason for ineffective cleaning at the apical third.

In the present study, compared to WO files, SAF resulted in complete removal of debris and better removal of smear layer especially in the apical third of the root canal. The cleaning efficacy of WO files in combination with newer irrigating devices could be assessed in future. Further studies shall be performed to verify if similar results can be attained with naturally occurring mixed bacterial biofilms and in curved root canals with complex anatomy. The cleaning efficacy of SAF can also be further explored with a combination of recently introduced irrigants.

## Conclusion

Within the limitations of this *in vitro* study, the SAF, operated with the continuous flow of 3% NaOCl and 17% EDTA, resulted in root canals that were almost completely free of debris and smear layer at coronal, middle, and apical thirds of root canal walls. With WO, optimal cleanliness could be achieved in coronal and middle third, but smear layer could not be eliminated completely in apical third.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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