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Research Article

THE SHAPING ABILITY OF TWO RECIPROCATING FILE SYSTEMS IN S-SHAPED SIMULATED ROOT CANALS

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ABSTRACT

Aim: The aim of this study is to evaluate the shaping ability of two reciprocating file systems (Wave One and Safe Siders) in comparison with the hand instrument (K-file) during the preparation of S-shaped simulated root canals.

Materials and Methods: Sixty (n=60)S-shaped endodontic resin training blocks were divided into three groups (n=20) according to the type of file used to prepare the canals (Wave One , SafeSiders and K-files). Pre and post instrumentation images were recorded and superimposed after preparation, images were analyzed by (AutoCAD 2008). Comparison among the different files was evaluated for the working length change, canal aberration and width measurement assessment (total, inner and outer) at different points : half-way to orifice, beginning of the first curve, apex of the first curve, apex of second curve and apical end. Data were analyzed using one way ANOVA, Tukey HSD, paired T-test, and Fisher's Exact test.

Results: less working length change was found in Wave One system with no significant difference between Wave One and Safe Siders instrumentation systems, all the three instrumentation systems showed high incidences of canals aberration, and in width measurement there was a significant difference between the mean values of total width of material removal among the three system at (half-way to orifice, beginning of 1st curve and apical end), there was a significant difference between the mean values of inner width of material removal among the three system at (half-way to orifice, beginning of 1st curve and apex of 1st curve), and there was a significant difference between the mean values of outer width of material removal among the three system at all measuring points (half-way to orifice, beginning of 1st curve, apex of 1st curve, apex of 2nd curve and apical end).

Conclusion: Wave One instrument systems, showed less canals length changes .None of the three instrumentation systems maintain the anatomy of S-shaped canals.

INTRODUCTION

Cleaning and shaping of the root canal system is the main objective of root canal treatment, the biological objective is to clean the root canal system of the bacteria, bacterial byproducts, maintain the health of periradicaler tissue by preventive the forcing of debris and help of healing of tissue by creation of sufficient space for intra- canal medicaments and subsequent obturation (Schilder, 1974).

Schilder in (1974), give five mechanical objective which help to end the root canal treatment with continuously funnel shape with the smallest diameter at the apical end and the largest diameter of the orifice to gather with maintaining the original shape of root canal that help provide space for placing the obturation material.

Endodontic treatment started with hand instrument made from stainless steel which consider stiff material, using stainless steel hand files caused more canal transportation and required long preparation time (Li *et al*., 2004). Stainless steel files resulted in a significantly greater loss of the working length (Krishna *et al.*, 2010).

There is an agreement in the literature that instrumentation of curved canals is considered a great challenge and canals with curves in multiple spatial orientations "double curvatures or S-shaped canals" predisposes higher risks of accidents (Bartha *et al.*, 2006). The morphology S-shaped root canals often carry the greatest challenges in their endodontic management. Failures in such cases are primarily related to procedural errors such as ledges, fractured instruments, canal blockages, zip and elbow creations.

To overcome the rigidity of stainless steel files, Nickel Titanium (NiTi) files were introduced in endodontic treatment,

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which are known for their flexibility in bending and torsion, as well a superior resistance to corrosion, compared with stainless steel files (Kazemi *et al.,* 2000), the file is able to return to its original shapes, due to its pseudo elastic properties (shape memory) (Vaudt *et al.,* 2007).

Reciprocation defined as any repetitive back and forth motion. Using of reciprocating motion resulting in the more canal centered when compare with continuous rotation (Franco *et al.,* 2011). Reciprocating motion in curved root canals will increase the lifespan of nickel-titanium rotary file (You *et al.,* 2010).

Wave One single file system uses under reciprocating motion. A study showed the Wave One Primary reciprocating single-file has better maintained the original canal anatomy, with less modification of the canal curvature in resin block in comparing with the Pro Taper system up to F2 (Berutti *et al.,* 2012).

The Safe Siders have a serial file system, stainless steel and (NiTi) files using under reciprocation motion.

The aim of this study is to evaluate the shaping ability of two reciprocating file systems (Wave One and Safe Siders) in comparison with the hand instrument (K-file) during the preparation of S-shaped simulated root canals.

MATERIALS AND METHODS

Resin blocks

Sixty endodontic-training blocks with S-shaped canals (Endo training block-S; Dentsply-Maillefer, Ballaigues, Switzerland), each with a 20 degree apical curvature and 30 degrees of coronal curvature according to Schneider method (Cunningham and Senia, 1992) were used in this study. Two grooves were drilled in each block on outer and inner side of curvature using a high speed hand piece with a long taper diamond bur, with numbers to facilitate superimposed of the images.

Sample distribution

The resin blocks were subdivided into three groups (n=20). The first group was prepared with Wave One Primary files (Dentsply-Maillefer, Ballaigues, Switzerland) with reciprocation motion 150 degree CCW and 30 degree CW. The second group was prepared with SafeSiders systems (Essential Dental Systems, South Hackensack, NJ, USA) with 30 to 60 degree reciprocation motion. The third group (control group) was prepared with hand K-file stainless steel hand instrumentation (Dentsply-Maillefer, Ballaigues, Switzerland) using a step-back-back preparation technique.

Preoperative imaging

A preoperative image of each simulated resin block was recorded by a digital microscope (Dino-Lite, Taiwan, AM413ZT) that has 1.3 megapixels sensor and up to 8×magnification. In order to get a standardized and reproducible picture, an accessories Dino-Lite stand MS35B was used for the best fitting of a digital microscope. A digital microscope was placed at a fixed distance (7 cm) form the block. A custom made template was made from self-cured acrylic to ensure placement of the block in a fixed place under digital microscope lens in mesio-distal view. Each canal was injected with red ink before taking the image, and the image was saved as a JPEG file**(Figure1).**

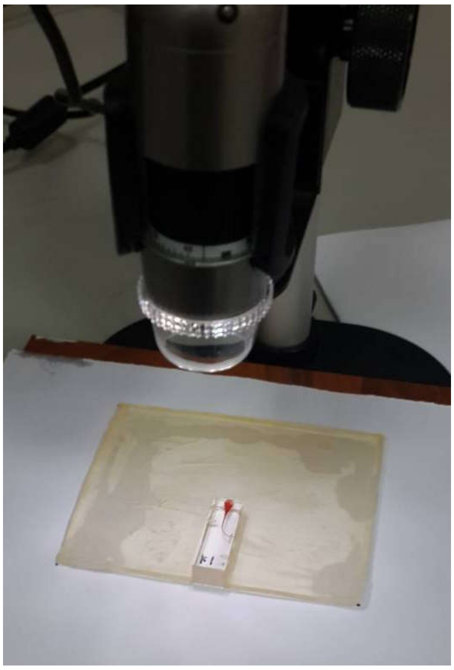

Figure 1 Digital microscope attached to Dino-Lite stand and placed at a fixed distance from the sample.

Simulated canal preparation

Simulated canals were instrumented to the full working length (16 mm), the length was measured by using digital calipers (Caliper, Steco, Germany) after recording a preoperative image.

Distilled water used as irrigation with a disposable syringe, gauge 27 needle and EDTA (Cream for root canal cleaning and preparation, META BIOMED, Korea) as a lubricant. Glide path with K- files (Dentsply-Maillefer, Ballaigues, Switzerland) size 08/0.02 and 10/0.02 was created prior to instrumentation with the all the groups. Each file was used to enlarge four canals only (Saber *et al.,* 2014; Bürklein *et al.,* 2012).

Group I: Twenty(n=20)simulated root canals were prepared using Wave One Primary files tip size 25 in a reciprocating motion as manufacturer's instruction using crown down preparation technique with the reciprocation hand piece (Dentsply-Maillefer, Ballaigues, Switzerland) at 350 RPM speed. The shaping procedure started with slow in-and-out pecking motion. The flutes of the instrument cleaned after three pecks.

Group II: Twenty (n=20)simulated root canals were prepared using SafeSiders rotary system in a reciprocating motion as manufacturer's instructions using crown down preparation technique with the reciprocation hand piece Endo-Express®, Essential Dental Systems, South Hackensack, NJ, USA) at 2500 RPM speed. The shaping procedure started with (08/0.02, 10/0.02, 15/0.02, 20/0.02, Pleezer, 25/0.02, 30/0.02, 30/0.04, 35/0.02, 40/0.02, 25/0.06) to the full working length.

Group III: Twenty (n=20) simulated root canals, the control group was prepared using K-files stainless steel (Dentsply-Maillefer, Ballaigues, Switzerland) hand instrumentation using step-back preparation technique. The shaping procedure started with 15/0.02, 20/0.02/, 25/0.02 to the full working length, then step-back continuous with 30/0.02 (W.L-1), 25/0.02 (W.L), 35/0.02 (W.L-2), 25/0.02 (W.L), 40/0.02 (W.L-3), 25/0.02 (W.L).

Assessment of canal preparation

A post-operative image of each sample shoot in the same conditions used in shooting the pre-operative image after injecting the block with red ink. The preoperative and post-operative images were superimposed using imaging software (Adobe Photoshop Cs4). The composite image was assessed using a computer program AutoCAD 2008 (Autodesk, SanRafeal, CA, SA).

Working length change

Following preparation, the final length of each canal was remeasured after preparation using digital calipers (STECO, Germany). A#25 K-files (Dentsply-Maillefer, Ballaigues, Switzerland) was inserted into the prepared canal. The final length of the canal, then subtracted from the original length to give the loss of working length (Yoo and Cho, 2012).

Canal aberrations assessment

Each simulated resin block was assessed for the presence of canal aberrations, including, zip and elbow, ledges, perforation, danger zone and coronal narrow, according to (Al-Omari *et al.,* 1992A; Al-Omari *et al.,* 1992 B).

1. **Apical zip**: irregular widening of the area at the endpoint of the canal where the resin had been largely removed from the outer aspect of the curve.
2. **Elbow**: a narrow region of the canal associated with and coronal to a zip.
3. **Danger zone**: excessive removal of resin from the inner aspect of the curve.
4. **Coronal narrow**: a narrowing of the canal associated with and coronal to a danger zone.
5. **Perforation**: a separate and distinct false canal towards the end-point of the canal which was not confluent with the original canal and which occurred along the outer aspect of the curve.
6. **Ledge:** a distinct irregularity along the outer wall of the canal at or near the curve, not substantial enough to be considered a perforation.

Width measurements

The amount of resin removed as a result of instrumentations was measured at fixed measurement position points at the inner side of curvature, outer side of curvature and total amount removed.

Superimposed image using Adobe Photoshop detailed the outline of the original canal per-operative and the outline of the canal post-operative; it was possible to quantify the amount of resin material removed by measuring the difference in width between the original canal and prepared canal. All measurements were made by drawing a line perpendicular to the axis of the original canal and converted into 'real' distances using a computer program AutoCAD 2008. Measurements were taken at fixed measurement position in the canals. The total width of the prepared canal and the width of the resin removed from the outer and inner aspects of the curve from the original canal to prepared canal were determined.

The removed resin was calculated at five different points using Yoshimine *et al.,* (2005) **(Figure 2)**.

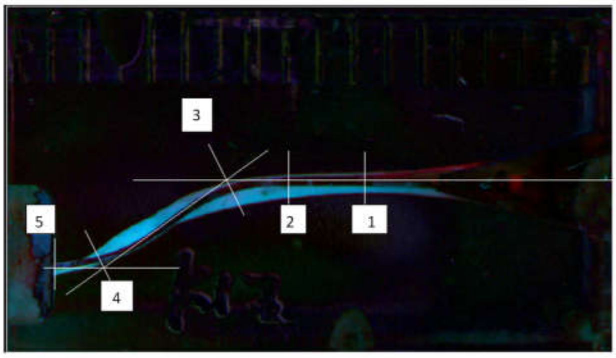

Figure 2 Superimposed image shows the five assessment levels in S-shaped canal: Position 1: half way to orifice, Position 2: beginning of the first curve, Position 3: apex of the first curve, Position 4: apex of second curve and Position 5: apical end.

Position 1: Half-way from the beginning of the curve to the orifice.

Position 2: Beginning of the first curve. This was determined as the point where the canal starts to deviate from the long axis of the straight part of the canal at the first curve.

Position 3: Apex of the first curve. This was determined by the intersection of two lines, one drawn along the outer border of the straight part of the canal and the second drawn along the outer border of a line extending between the two curves.

Position 4: Apex of second curve. This was determined by the intersection of two lines, one drawn along the outer border of a line extending between the two curves and the second drawn along the outer border of the apical aspect of the canal.

Position 5: Apical end, this represents the end point of the preparation.

Statistical analysis

All data recorded and stored on PC and analyzed using the SPSS statistical analysis program. Working length changes and width measurements between systems were analyzed using one way ANOVA and Tukey HSD, width measurements within the systems were analyzed using paired T-test whiles canal aberrations were analyzed using Fisher's Exact test. Probability of $P<0.05$ was set as a reference for statistical significance.

RESULTS

Working length changes

The mean loss of working length that occurred with different instrumentation methods is shown in **Table 1.** There was a significant difference in the loss of working length between the three groups ($P=0.007$). Wave One has less working length change which is significantly less compared with K-files. There was no significant different between working length change in canals prepared by Safe Siders and K-files.

Table 1 Working length change within the three instrumented groups

Instrument systems	WaveOne Mean±SD	SafeSiders Mean±SD	K-files Mean±SD	ANOVA P-value
Working length changes (mm)	0.161[a]±0.276	0.687[a,b]±0.870	0.881[b]±0.822	0.007

SD: Standard Deviation
[a,b,c] P<0.05 The identical letters in each row illustrate the values which present no significant difference.

Incidence of canal aberration

Regarding the incidence of canal aberrations, the results are summarized in **Table 2**.

Table 2 Incidence of canal aberration

Canal aberration	WaveOne% (n=20)	SafeSiders% (n=20)	K-files% (n=20)	Significance
Apical zip	70%	80%	85%	0.630
Elbow	70%	80%	85%	0.630
Danger zone 1st	50%[a]	100%[b]	100%[b]	0.000
Coronal narrow1st	50%[a]	100%[b]	100%[b]	0.000
Danger zone 2nd	70%[a]	100%[b]	100%[b]	0.002
Coronal narrow2nd	70%[a]	100%[b]	100%[b]	0.002
Perforation	0	0	0	1.0
Ledge	10%	10%	15%	1.0

[a,b,c] P<0.05 The identical letters in each row illustrate the values which present no significant difference.

Apical zip/Elbow

There was no significant difference in apical zip and elbow incidence among the three groups (P=0.630).

Danger zone 1st/Coronal narrow1 st

There were significant differences among the three groups (P=0.000). Wave One has a lower percentage of danger zone 1st and coronal narrow1st incidence in comparison with SafeSiders and K-files, with no significant differences between SafeSiders group and K-files group.

Danger zone 2nd/ Coronal narrow2nd

There were significant differences among the three groups (P=0.002). Wave One has a lower percentage of danger zone 2nd and coronal narrow2nd incidence in comparison with Safe Siders and K-files, with no significant differences between Safe Siders group and K-files group.

Ledge

However, there was no significant difference in ledge incidence among the three groups (P=1.0).
No perforation was observed among the three groups

Width measurements within each system

Wave One

Statistical analysis using a paired T-test revealed that there was a significant difference between the outer mean values and inner mean values at all measurement points except at apex of 2nd curve, in Wave One system **(Figures 3 and 4).**

Safe Siders

Statistical analysis using a paired T-test revealed that there was a significant difference between the outer mean values and inner mean values at all measurement points except at half way to orifice, in SafeSiders system **(Figures 5 and 6).**

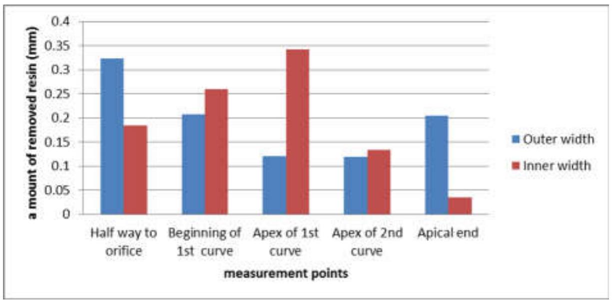

Figure 3 Outer and inner width measurements in S-shaped canals prepared with WaveOne system.

Figure 4 S-shaped canal prepared with WaveOne system.

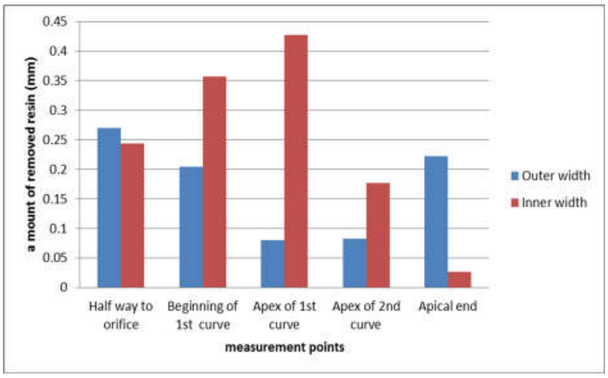

Figure 5 Outer and inner width measurements in S-shaped canals prepared with SafeSiders system.

Figure 6 S-shaped canal prepared with SafeSiders system.

K-files

Statistical analysis using a paired T-test revealed that there was a significant difference between the outer mean values and inner mean values at all measurement points except at half way to orifice, in K-files system **(Figures 7 and 8).**

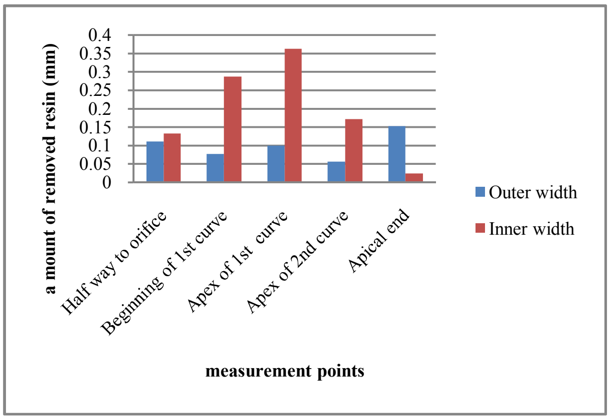

Figure 7 Outer and inner width measurements in S-shaped canals prepared with K-files system.

Figure 8 S-shaped canal prepared with K-files system.

Width measurements between the systems

The mean values of the total width of canals prepared with the three systems are summarized in the **Table 3.**

Table 3 The mean values of the total width of canals prepared with WaveOne, SafeSiders and K-files

Instrument types / Measurement points	WaveOne Mean±SD (mm)	SafeSiders Mean±SD (mm)	K-files Mean±SD (mm)	ANOVA P-value
Half way to orifice	0.817^{a}±0.054	$0.834^{a,c}$±0.034	0.567^{b}±0.021	0.000
Beginning of 1st curve	0.724^{a}±0.030	0.818^{b}±0.057	0.620^{c}±0.037	0.000
Apex of 1st curve	0.722±0.026	0.755±0.102	0.730±0.037	0.244
Apex of 2nd curve	0.422±0.034	0.449±0.116	0.412±0.074	0.348
Apical end	0.407^{a}±0.062	$0.420^{a,b}$±0.127	0.347^{a}±0.067	0.031

SD: Standard Deviation
^{a,b,c} P<0.05 The identical letters in each row illustrate the values which present no significant difference.

The one way ANOVA test revealed that there was a significant difference between the mean values of the total width of material removal among the three systems at (half way to orifice, beginning of 1st curve and apical end)**(Figure 9).**

The mean values of the outer width of canals prepared with the three systems are summarized in the **Table 4.** The one way ANOVA test revealed that there was a significant difference between the mean values of the outer width of material removal among the three system at all measuring points (half way to orifice, beginning of 1st curve, apex of 1st curve, apex of 2nd curve and apical end)**(Figure 10).**

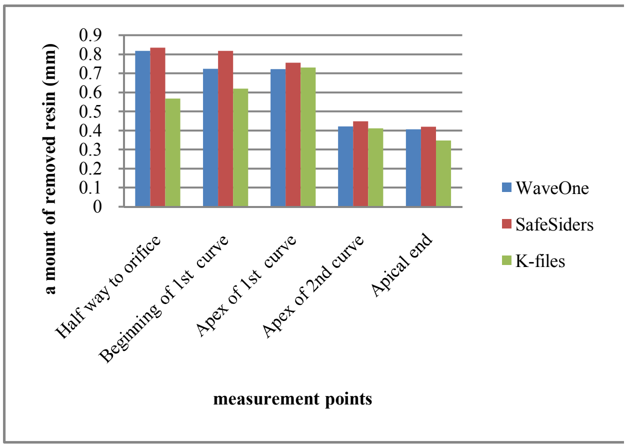

Figure 9 Total width measurements in S-shaped canals prepared with WaveOne, SafeSiders and K-files.

Table 4 The mean values of the outer width of canals prepared with WaveOne, SafeSiders and K-files

Instrument types / Measurement points	WaveOne Mean±SD (mm)	SafeSiders Mean±SD (mm)	K-files Mean±SD (mm)	ANOVA P-value
Half way to orifice	0.323^{a}±0.053	0.270^{b}±0.038	0.111^{c}±0.048	0.000
Beginning of 1st curve	0.208^{a}±0.055	$0.204^{a,c}$±0.034	0.077^{b}±0.035	0.000
Apex of 1st curve	0.120^{a}±0.034	$0.080^{b,c}$±0.059	$0.100^{a,c}$±0.045	0.037
Apex of 2nd curve	0.119^{a}±0.028	0.083^{b}±0.033	0.056^{c}±0.024	0.000
Apical end	0.204^{a}±0.056	$0.222^{a,b}$±0.127	0.153^{a}±0.064	0.046

SD: Standard Deviation
^{a,b,c} P<0.05 The identical letters in each row illustrate the values which present no significant difference.

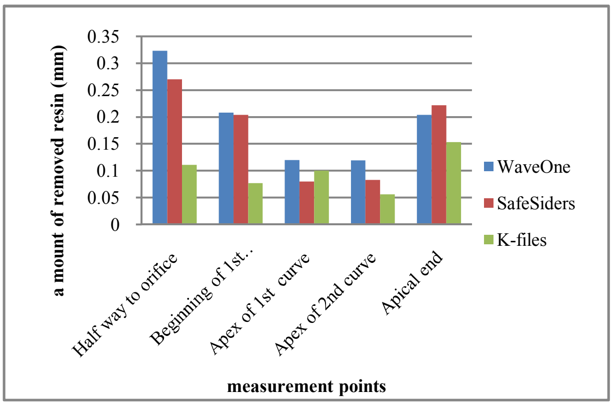

Figure 10 Outer width measurements in S-shaped canals prepared with WaveOne, SafeSiders and K-files.

Instrument types / Measurement points	WaveOne Mean±SD (mm)	SafeSiders Mean±SD (mm)	K-files Mean±SD (mm)	ANOVA P-value
Half way to orifice	0.184^{a}±0.047	0.244^{b}±0.049	0.133^{c}±0.053	0.000
Beginning of 1st curve	0.259^{a}±0.050	$0.357^{b,c}$±0.063	0.287^{a}±0.057	0.000
Apex of 1st curve	0.342^{a}±0.042	$0.428^{b,c}$±0.064	0.363^{a}±0.053	0.000
Apex of 2nd curve	0.133±0.068	0.177±0.122	0.172±0.087	0.287
Apical end	0.035±0.015	0.027±0.025	0.024±0.019	0.259

SD: Standard Deviation
^{a,b,c} P<0.05 The identical letters in each row illustrate the values which present no significant difference.

The mean values of the inner width of canals prepared with the three systems are summarized in the Table 5. The one way ANOVA test revealed that there was a significant difference between the mean values of inner width of material removal among the three systems at (half way to orifice, beginning of 1st curve and apex of 1st curve) (Figure 11).

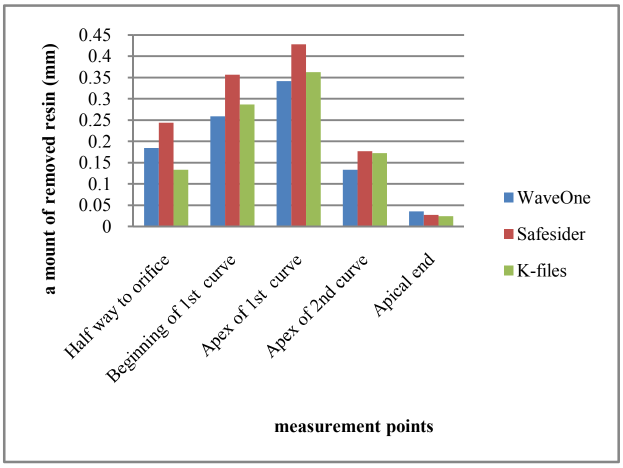

Figure 11 Inner width measurements in S-shaped canals prepared with Wave One, Safe Siders and K-files.

DISCUSSION

Method

The aim of our study to compare the shaping ability of the two reciprocation system using Wave One and SafeSiders based on different reciprocation motion in comparison to the hand K-files using step-back technique as standard technique by determined the working length change, canal aberration and width measurement by determining the total amount of the resin that removes from the outer (concave) and the inner (convex) sides of the curvature in S-shaped simulated resin blocks. As previous studies have been demonstrated using of endodontic instruments in reciprocating motion, maintaining the original curvature of canal (Berutti *et al.,* 2012; Franco *et al.,* 2011; You *et al.,* 2011).

Photographic assessment in resin blocks has been used in several previous studies as an assessment method for shaping ability of the rotary system (Madureira *et al.,* 2010; Suneelkumae *et al.,* 2010; Aydin *et al.,* 2012; Goldberg *et al.,* 2012; Muňoz *et al.,* 2014; Dhingra *et al.,* 2014).

To assess the shaping ability of different endodontic system an experimental model have been used both in simulated curved canals and human teeth. In contrast to using human teeth in the assessment of shaping ability of the endodontic system simulated curved canal in resin block are able to provide standardizes condition in term of diameter, length and angle of canal curvature and consider as an ideal experimental model to allow direct comparison of the shaping ability of different system (Schäfer *et al.,* 1995). This method of assessment based on the superimposition of pre and post-operative images which provide the information about incidence of canal aberration and help in measurement the amount of material removed at each evaluation points which reflects the behavior of the instrument in several critical points along the canal.

However the hardness difference between dentin and experimental resin should be taken in consideration in extrapolating of the resistance to the clinical situation (Peters 2004; Suneelkumar *et al.,* 2010). Another drawback of using rotary instruments in resin block is heat generation, which may soften the resin material (Kum *et al.,* 2000).

Each instrument has been used for four times as the Wave One single-file reciprocating system is recommended to be used as single-patient instruments, and most of times the maximum number of root canals per tooth is four (Saber *et al.,* 2014) and we applied this principle for all systems to have the standardization.

Working length change

Our study showed working length changes occurred in canals with all instrumentation systems following the preparation. There was no significant difference between Wave One and SafeSiders groups, as there is no study to compare between Wave One and SafeSiders in S-shaped canals. Zhang *et al.,* (2008) and Yoshimine *et al.,* (2005) reported that the greater taper of instrumentation file may be responsible for transportation and straightening effect in S-shaped canals when used ProTaper F3, this could be related reason for the working length change with Wave One and SafeSiders.

Similarly, there was no significant difference between working length change in canals prepared with SafeSiders and K-files instrumentation systems, as SafeSiders system mainly composed of stainless steel instruments with few (NiTi) instruments, this observed is consistent with the investigation of (Krishna *et al.,* 2010) who compared (NiTi) files to stainless steel files they found greater working length change with stainless steel files. The possible reasons are due to less flexible instruments with a tendency to straightening of curved canals during canal preparation (Schäfer 1995; Thompson and Dummer, 2000A).

Canal aberrations

All the systems shown high incidence of canal aberration, although there is a significant difference between Wave One and other two systems in danger zone 1st, coronal narrow 1st and danger zone 2nd, coronal narrow 2nd. This result was consistent with the investigation Bürklein *et al.,* (2014) as he found the highest number of canal aberration in Wave One system in the S-shaped canal, and with Ajuz *et al.,* (2013) for K-files. We could not find any study conducted with SafeSiders in S-shaped canals. The possible reason for that the more tapered files, less flexible file (Bürklein *et al.,* 2014; Bonaccorso *et al.,* 2009; Zhang *et al.,* 2008; Yoshimine *et al.,* 2005) and the complexity of S-shaped canal (Yoshimine *et al.,* 2005) caused more canal aberration.

Width measurements

The Wave One instrumentation system showed greatest resin material removed, especially on the inner width of beginning of 1st curve, apex of 1st curve and the apex of 2nd curve, although there is no significant difference on the material removed between outer and inner width at apex of 2nd curve with more martial removed from the outer side at apical end resulting in a marked straightening of the canals. With no significant difference between Wave One instrumentation system and K-files instrumentation system at same point and no significant difference between Wave One instrumentation system and

SafeSiders instrumentation system at apex of 2nd curve and apical end.

This result is consistent with (Bürklein *et al.,* 2014) as Wave One groups and Reciproc groups had the greatest number of canal aberration in comparing with, HyfleexCM, F360 and OneShape in resin block. The most common reason for that (NiTi) files with tapers greater than 0.04 should not be used in S-shaped canal preparation (Bürklein *et al.,* 2014; Bonaccorso *et al.,* 2009; Zhang *et al.,* 2008; Yoshimine *et al.,* 2005).

The SafeSiders instrumentation system showed that the greatest resin material has been removed, especially on the inner width of beginning of 1st curve, apex of 1st curve and apex of 2nd curve with more martial removed from the outer width at apical end resulting in a marked straightening of the canals. With no significant difference between SafeSiders instrumentation system and K-files instrumentation system at apex of 2nd curve. Eid and Amin, (2011) reported that better shaping of H-files and ProTaper Universal than SafeSiders reciprocating instrument in the oval shape canal, as there is no study conduct to see the effect of SafeSiders reciprocating instrument in S-shaped canal. The main reason for that the larger size stainless steel files within the SafeSiders system the more the rigidity of files the more canal straightening (Rhodes *et al.,* 2011).

K-files instrumentation system showed greatest resin material removed, especially on the inner width of beginning of 1st curve, apex of 1st curve and apex of 2nd curve with more martial removed from the outer width at apical end resulting in a marked straightening of the canals. This result is in agreement with previous studies Ding-Ming *et al.,* (2007); Madureira *et al.,* (2010); Ajuz *et al.,* (2013) and Can *et al.,* (2014) they found more material from the inner width of both curvature and more incidence of apical transportation with hand instrumentation stainless steel K-files in simulated S-shaped canals. The main reason for that less flexible instrument will increase transportation in the original canal (Ding-Ming *et al.,* 2007; Bonaccorso *et al.,* 2009; Madureira *et al.,* 2010).

CONCLUSIONS

1. None of the three instrumentation systems maintain the anatomy of S-shaped canals as shown in width measurement.
2. All the three instrumentation systems showed high incidences of canals aberration.
3. Less working length change was found in the Wave One system with no significant difference between Wave One and SafeSiders instrumentation systems, with no significant difference between working length change in canals prepared with SafeSiders and K-files instrumentation systems.

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