No Difference in Root Canal Instrumentation of the Apical Third Between Reciproc® and Waveone®

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Abstract

Most instrumentation techniques leave 35% or more of the root canal wall non-instrumented due to the oval shape of the apical third of the root canal wall. Oscillation movement instruments have claimed to clean the whole area of the root canal wall while maintaining the original canal shape during preparation. Objective: To compare the non-instrumented area at the apical third of the root canal wall after preparation using Reciproc® and WaveOne® oscillation instruments. Method: The pulp tissues of 32 human mandibular premolars were removed and the root canals were filled with China ink. Of these teeth, 16 were instrumented with the R25 Reciproc® instrument with VDW Silver Reciproc® endomotor. The other 16 teethwere instrumented with the WaveOne® Primary 25/08 file with WaveOne® endomotor. Roots were bisected longitudinally in a buccolingual direction, photographed, and analyzed using Adobe Photoshop CS5 software. The apical third of the canal walls were evaluated for total canal wall area versus remnant non-instrumented area on which China ink remained. Results: WaveOne® had a lower percent of non-instrumented area than Reciproc®, but this difference was not statistically significant (P=0.27). Conclusion: There are no significant difference between the percentage of non-instrumented area at the apical third of the root canal wall after instrumentation by Reciproc® and WaveOne®. While the observed differences were not significant, root canal walls instrumented by WaveOne® had a lower percent of non-instrumented area.

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Introduction

Instrumentation plays a key role in successful root canal preparations. Instruments should be able to shape the canal, optimizing the canal irrigation and obturation[1]. Morphology of the canal affects the cleanliness of root canal preparation, especially around the apical third. Silveira et al.[2] explained that even crown down techniques only clean around 40% of apical walls. Many areas in the apical third remain unprepared due to the oval or irregular configuration. Jain and Bahuguna[3] highlighted that the apical third of the root canal is the area with the most ramifications (84.74%).[3]

According to Câmara et al.[4], a root canal instrument that can prepare the entire canal wall has not yet been developed. Current instruments have a rounded shape that do not suit canal's ovoid shape. The development of an instrument that can prepare the entire canal wall is therefore required[4]. Indari[5] found that instrumentation with ProTaper (push-pull filing), Hero Shaper (rotary circumferential filing) and Light Speed (pecking motion) left non-instrumented areas at the apical third. Peters[6] found that if the anatomy of the apical third is not well prepared, it may cause the advancement of disease into the periapex.

With the development of newer hand pieces and rotary files, root canal preparation nowadays can be done more efficiently. A rotary handpiece with appropriate torque simplifies

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and standardizes root canal preparation procedures. However, rotary instruments cannot be used in calcified canals, ledges, curved canals, type II root canal configurations (two canals merging into one apical foramen), and S-shaped canals.[7] Rotary instruments can be very aggressive and can lack nuanced control, which can lead to fracturing of the instrument within the canal. A fracture may occur due to torsional and/or flexural fatigue. Torsional fatigue happens when a part of the instrument is stuck inside the canal while the instrument keeps rotating. Circumstances that would lead to continued rotation of a lodged instrument include excessive pressure on the hand piece, a large contact area between root canal surfaces and the instrument's cutting edges, and a smaller canal size compared to the non-active/ non-cutting tip of the instrument.[7] This final circumstance may cause taper lock, especially in instruments with greater tapering under certain sequences.

After the rotary generation, handpieces with oscillating movements were developed to reduce instrument breakage and inefficient preparation. Oscillating (rotating back and forth) creates a reciprocal movement. The principle of this movement is watch-winding, which is less aggressive compared to rotary, and it is suitable for exploring and enlarging a small or calcified canal with a small-sized file and light movements.[8] Oscillating movements move the instrument into every direction with short amplitudes, decreasing the risk of cyclic fatigue while optimally cleaning the entire canal wall and preserving the original anatomy.[9]

The introduction of Reciproc® and WaveOne® in the market changed the root canal preparation paradigm. With these instruments, it is now possible to finish a root canal preparation with a single file regardless of whether it is a narrow or curved canal. Furthermore, a glide path is no longer compulsory.

The efficacy of oscillating instruments in preparing the root canal has yet to be fully studied. A previous study[10] compared Reciproc® and WaveOne® files with two rotary files of a similar cross-section (Mtwo and ProTaper). This study showed that all four products could preserve the curvature and natural shape of the canals and were safe to be used. Mtwo and Reciproc® showed higher levels of cleanliness at the apical third of the canal compared to ProTaper and WaveOne®.[10] However, research on preparation at the apical third using oscillating movements with a single file system has not been conducted. This study compared the percentage of non-instrumented area at the apical third of the root canal left by Reciproc® and WaveOne® using mandibular premolar root canals.

Methods

The methods of this study matched those of Grecca et al.[11] who conducted a quantitative analysis on root canal preparation using rotary instruments, ultrasonic instruments and manual techniques in proximally flattened root canals. Mandibular premolars (n=32) with single, straight canals, apical inclinations of 0-5˚, and lengths of 18-24 mm underwent access preparation (*Access Bur Kit*, Dentsply, Tulsa) and pulp tissue extirpation. The samples' working length were determined visually by canal exploration using a No.10 K-file until it reached the apical foramen, after which the file was reduced by 1 mm. The samples' starting file was determined by using a No.15 K-file and was confirmed with a radiographic evaluation.

China ink (1 mL) was injected into the root canal through the canal orifice using an insulin syringe and a 31-gauge irrigation needle until there was ink visibly coming out from the apical foramen. Ink was applied to the canal walls evenly with the help of a sonic instrument (*EndoActivator*, Dentsply, Tulsa) for 1 minute and each tooth was then left at room temperature for 48 hours until the ink had completely dried (Figures 1a and 1b). Samples were then randomly divided into two groups for preparation by the two different instruments, Reciproc® (n=16) and WaveOne® (n=16).

Reciproc® and WaveOne® instruments were chosen for this research since both instruments apply the oscillating movement principle in a single use, single file system. Both instruments had similar file tip diameters and tapering degrees (25/08, R25 file for Reciproc® and Primary 25/08 for WaveOne®). The Primary 25/08 file has continuously decreasing tapering degrees from the tip to the shaft of the file (0.8, 0.65, 0.6, 0.55) and two different cross-sections along the active part of the file. At the tip of the file, the cross-section shape is

modified to a convex triangle with a radial land, whereas at the middle and shaft, the cross-section shape is a convex triangle with a neutral rake angle. The R25 file has a continuous tapering degree for the first 3 mm of the file's active zone, which then gradually decreases toward the shaft of the file. The R25 has an S-shaped cross-section along the file's active working zone.

Reciproc® samples were prepared using the R25 Reciproc® instrument with VDW Silver Reciproc® endomotor. A glide path was made using No.10 and No. 15 K-files. Early preparation was done along two-thirds of the working length with in and out pecking motions under light pressure without pulling the instrument entirely out of the canal.

After every three in and out movements, the instrument was removed from the canal and the flutes were cleaned. This was also done when more pressure was needed for the instrument to go into the canal and when resistance was felt inside the canal. After early preparation was complete, the root canal was irrigated with 2 mL of 2.5% NaOCl and dried with paper points.[10] Preparation continued with similar movements until the working length was achieved.

WaveOne® samples were prepared using a WaveOne® Primary 25/08 file with WaveOne® endomotor. A glide path was made using No.10 and No. 15 K-files. Files were inserted progressively with no pressure into the canal for 2 mm, 3 mm,and 4 mm. When resistance was encountered or if the file couldn't enter easily, the file was taken out slowly and its flutes were cleaned.

The canal was then irrigated with 2 ml of 2.5% NaOCl and dried with paper points.[12] Preparation then continued with similar movements until the working length was achieved. In both groups, the root canal preparation was combined with brushing movements. After every 4 root canal preparations in a group, the file was replaced.

After preparation was finished for all samples, access was sealed with glass ionomercement (*Fuji IX*, GC Corp, Japan). Samples were cut longitudinally in a buccolingual direction using a stainless-steel chisel (Figure 1c). After that, samples were cut horizontally 5 mm from the root canal apex.

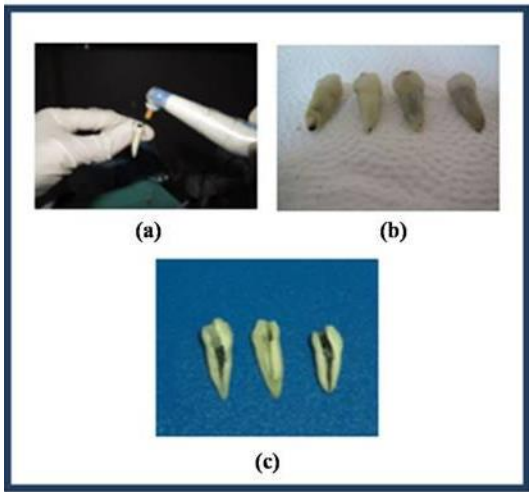

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Figure 1. Sample preparation sequence: China ink being inserted into the root canal with the aid of sonic equipment (a); samples filled with China ink (b); longitudinally cut samples (c).

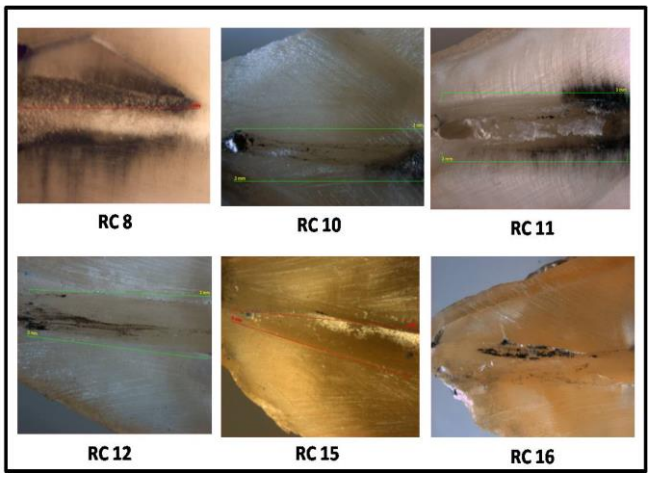

Figure 2. Samples from the Reciproc® group showing canal walls with china ink residue (RC 8, 10, 11, 12 and 16) and without (RC 15). Reciproc® preparation were conducted usingR25 VDW Silver Reciproc® endomotor

Samples were placed in an upright position and observed using a stereo microscope (*SteREO Discovery.V12*, Carl-Zeiss, Germany) under 20x magnification. Cross-sections were captured with a digital camera (Figure 2 and 3). Remnants of the China ink were measured using Adobe Photoshop CS5 software (unit=pixels).

The percentage of unprepared walls (indicated by China ink remnants) in the apical third of the prepared canals were calculated (Figure 4).

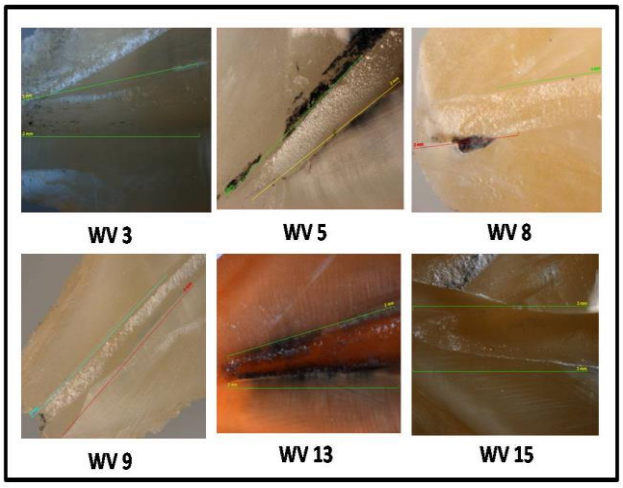

Figure 3. Samples from the WaveOne® group showing canal walls with china ink residue (WV 3, 5, 8 and 13) and without (WV 9 and 15). WaveOne® preparation were conducted using WaveOne® Primary 25/08 file with WaveOne® endomotor.

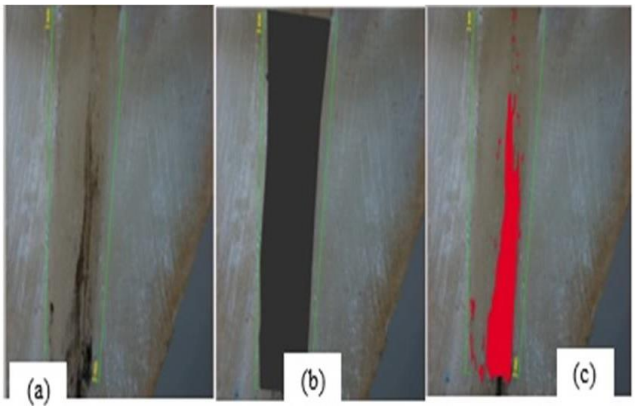

Figure 4. Photo of China ink remnants (a), the area of the apical third as calculated by the software (b), and the unprepared area calculated by the software. (c) In this sample, the apical third had a total area of 333776 pixels and an unprepared area of 86294 pixels, resulting in a unprepared area percentage of 25.85%.

Due to the abnormal distribution of the data, the results were analyzed using a Mann-WhitneyU test to determine the differences in unprepared canal walls percentages at the apical third after using the oscillating instruments Reciproc® and WaveOne®. The significance level was set at $P<0.05$.

Results

There were ink remnants found after preparing the root canals using both of the oscillating instruments. As seen in Table 1, onlythree samples from each group showed a perfect preparation score of 0%. This study showed better results, with the lowest score being 0% and highest score being 31.46% for all samples. WaveOne® left a lower percent area of unprepared canal wall compared to Reciproc®. The Mann-Whitney U test showed that there was no significant difference ($P=0.27$) between the average percentage of non-instrumented area inthe apical third of the root canal wall after instrumentation by Reciproc® and WaveOne® (Table 2).

Table 1. Percentage of unprepared canal walls (evidenced by ink remnants) at apical third after preparation using Reciproc®and WaveOne® oscillating instruments.

Sample No.	Reciproc® Sample No.	Ink Remnants for Reciproc® (%)	Sample No.	WaveOne® Sample No.	Ink Remnants for WaveOne® (%)
1.	RC 1	2.120	17.	WV 1	2.014
2.	RC 2	31.455	18.	WV 2	0.329
3.	RC 3	9.666	19.	WV 3	4.176
4.	RC 4	21.566	20.	WV 4	4.375
5.	RC 5	4.280	21.	WV 5	0*
6.	RC 6	0*	22.	WV 6	9.388
7.	RC 7	3.682	23.	WV 7	3.198
8.	RC 8	28.935	24.	WV 8	2.674
9.	RC 9	0*	25.	WV 9	0*
10	RC10	24.025	26.	WV 10	6.007
11	RC 11	19.924	27.	WV 11	21.722
12	RC 12	19.841	28.	WV 12	3.308
13	RC 13	0*	29.	WV 13	21.843
14	RC 14	9.256	30.	WV 14	11.742
15	RC 15	0.798	31.	WV 15	0*
16	RC 16	11.931	32.	WV 16	9.690

*Showing score for perfectly cleaned canal walls.

Table 2. The average distribution of percentage of unprepared canal walls at the apical third after using oscillating instruments Reciproc® and WaveOne®. The significance level for the Mann-Whitney U test was set at $P< 0.05$

Groups	n	Average ± Deviation Standard	Confidence Interval 95% (Lower – Upper)	*p Value*
Reciproc®	16	11.717 ± 11.019	5.846 – 17.589	0.27
WaveOne®	16	6.279 ± 7039	2.528 – 10.030	

Discussions

This research was conducted on the apical third 5 mm from apex, since most unprepared canal walls (64%)[6] occur at 5 mm from apex and since the apical third is a crucial part that should be prepared due toits anatomical complexity. If micro organisms are left in this part, they can cause endodontic treatment failure.[6] Several methods employed to investigate the results of root canal preparation have included micro-computed tomography[13], scanning electronic microscopy (SEM)[10,14], artificial root canals made of resin polyester[15], computer software[10], root canal transparency[16], and the ink method.[11,14,17] Most of these techniques require high costs, especially those that use a great number of specimens. The ink method is usually applied to observe the area of unprepared canal walls since it adheres to unprepared areas after preparation. Silva et al.[17] used the ink method to compare preparation efficiency of different instrumentation methods by observing the remnants of ink found on canal walls.[17]

This research used China ink since the particle size of this ink is less than 3 µm, therefore enabling it to penetrate into dentinal tubules. China ink is inorganic and water insoluble, allowing it to remain when an organic dissolving irrigant such as NaOCl 2.5% is used. In this study, China ink reached the apical third of the canal with the help of a sonic irrigating instrument. Vibrations help deliver ink evenly to the apex, which is assured when ink comes out of the apical foramen.

Camps and Pertot (in Jeffrey et al., 2010) mentioned that a smaller cross-section may cause a larger gap between the instrument and the root canal, resulting in easier debris elimination.[18] A larger cross-section shape does not provide enough space for the debris and may hinder the instrument in dentinal cutting. In their study, an S-shaped cross-section showed less contact area between the instrument and the canal walls compared to a triangular shaped cross-section, which left some of the canal walls unprepared. However, an S-shaped cross-section provides the instrument with higher flexibility.[19]

Peters et al.[20] predicted that every root canal instrumentation method would leave at least 35% or more of unprepared canal wall area. Compared to that research, this study showed better results, with the lowest score being 0% and highest score being 31.46% for all samples. These results agreed with research conducted by Burklein et al.[10], which mentioned that there were unprepared areas at all regions of the root canal (coronal one-third, middle one-third and apical one-third) after preparation using Reciproc®, WaveOne®, Mtwo, and ProTaper. This findingis also supported by similar studies using micro-computed tomography.[13,20]

While the differences between Reciproc® and WaveOne® were not significant, WaveOne® left a lower percent area of unprepared canal wall compared to Reciproc® showing that the WaveOne® instrument prepared canal walls more effectively (Table 2). This may be due to the uniformity of apical diameter enlargement and tapering degree (25/08). The different rotating angles of both instruments are still being questioned today, but both have 120˚ in three cycles, creating 360˚ of movement.[13,19,21] As mentioned by Burklein et al.[10], both Reciproc® and WaveOne® showed good canal cleaning abilities with their single file systems.

The fact that the WaveOne® samples showed a lower percentage of unprepared canal walls could be explained by several theories. As mentioned by Ingle et al.[22], a triangular cross-section increases security,

cutting efficiency and tactile sensation during preparation while also reducing contact areas between the instrument and the canal walls. The Primary file with the triangular cross-section is also built with a tighter pitch at the tip of the file. The smaller the pitch or the shorter the distance between two pitches, more spiral are formed and the greater the helix angle.[23] The cutting ability of the instrument has demonstrated its efficacy in cutting dentin during root canal preparation. One of the factors affecting an instrument's cutting ability is the helix angle, which is the angle from cutting edge that is formed along the file's longitudinal axis.[23] According to Grande et al.[19] instruments with helical angles similar to reamer (45˚) show aggressive cutting performance when used in rotary motion compared to instrument with helix angles such as those of the K-file (30˚). The Primary file has a larger helical angle compared to R25 file and thus shows greater dentinal cutting performance.[19]

Conclusions

There are no significant difference between the percentage of non-instrumented area at the apical third of the root canal wall after instrumentation by Reciproc® and WaveOne®. While the observed differences were not significant, root canal walls instrumented by WaveOne® had a lower percent of non-instrumented area. Use of WaveOne® may result in more efficient instrumentation, though this would need to be confirmed in future studies. Further developments in root canal instrumentation should take into consideration the beneficial design elements of WaveOne®.

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Declaration of interest

The authors report no conflict of interest and the article is not founded or supported by any research grant.

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