Cutting Efficiency of Reciproc and WaveOne Reciprocating Instruments

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Abstract

Introduction: The aim of the present study was to evaluate the cutting efficiency of 2 new reciprocating instruments, Reciproc and WaveOne. **Methods:** Twenty-four new Reciproc R25 and 24 new WaveOne Primary files were activated by using a torque-controlled motor (Silver Reciproc) and divided into 4 groups (*n* = 12): group 1, Reciproc activated by Reciproc ALL program; group 2, Reciproc activated by WaveOne ALL program; group 3, WaveOne activated by Reciproc ALL program; and group 4, WaveOne activated by WaveOne ALL program. The device used for the cutting test consisted of a main frame to which a mobile plastic support for the handpiece is connected and a stainless steel block containing a Plexiglas block (inPlexiglass, Rome, Italy) against which the cutting efficiency of the instruments was tested. The length of the block cut in 1 minute was measured in a computerized program with a precision of 0.1 mm. Means and standard deviations of each group were calculated, and data were statistically analyzed with 1-way analysis of variance and Bonferroni test ($P < .05$). **Results:** Reciproc R25 displayed greater cutting efficiency than WaveOne Primary for both the movements used ($P < .05$); in particular, Reciproc instruments used with their proper reciprocating motion presented a statistically significant higher cutting efficiency than WaveOne instruments used with their proper reciprocating motion ($P < .05$). There was no statistically significant difference between the 2 movements for both instruments ($P > .05$). **Conclusions:** Reciproc instruments demonstrated statistically higher cutting efficiency than WaveOne instruments. *(J Endod 2014;40:1228–1230)*

Key Words

Cutting efficiency, cutting test, NiTi instruments, reciprocation

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0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2014.01.041

Endodontic nickel-titanium (NiTi) rotary and reciprocating files are useful and safe instruments for canal preparation, allowing efficacious preparation of even severely curved root canals and decreasing the working time (1, 2). With advancements in technology, endodontic instruments today come in a variety of designs, each differing in cost, performance, and safety (3).

One important attribute of an endodontic instrument is the cutting efficiency. It was assessed as changes in the dentin thickness removed and root canal volume (4), from weight loss of tooth samples (5) and resin blocks (6) after instrumentation, as a result of the debris generated during the preparation of extracted teeth (7), measuring the mass lost from a Plexiglas plate (inPlexiglass, Rome, Italy) by the instrument in cutting (8) or the maximum penetration depth of the instruments into the lumen of special plastic samples with a cylindrical canal (9), in terms of preparation time (10, 11), and from direct evaluation by a clinician during preparation (12).

The capability of a file to efficiently remove dentin is a complex interrelationship of different parameters including the number of flutes, cross-sectional area and design, sterilization, chip removal capacity, helical and rake angle, tip design, metallurgical properties, and surface treatment of the instruments (5, 6, 9, 13–17).

In 2008, a new preparation technique with only one ProTaper F2 instrument in a reciprocating motion was proposed by Yared (18). The use of reciprocating motion was shown to ultimately increase the life span of NiTi instruments in comparison with continuous rotation (19). Recently, 2 brands of NiTi instruments were introduced to the market that advocated the reciprocation concept, Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland). These manufacturers claim that the reciprocal motion would reduce the torsional stress by periodically reversing the rotation of the file, thus remaining under the plastic limit of the instrument (20). Reciproc R25 and WaveOne Primary are similar in size and manufacturing process. In fact, they both have tip size 25 with a variable taper that is 0.08 over the first apical 3 mm, are produced with M-wire NiTi, and have a left-handed angulation of the blades.

Although extensive studies were conducted on the cutting ability of hand and rotary endodontic instruments, there is a need for studies investigating the cutting efficiency of these new reciprocating systems. Therefore, the aim of the present study was to evaluate the cutting efficiency of Reciproc and WaveOne NiTi reciprocating instruments and their proprietary movement in a new device specifically developed for cutting tests.

Materials and Methods

A total of 48 new NiTi reciprocating instruments 25 mm in length were used in the present study, 24 Reciproc R25 and 24 WaveOne Primary files. Subsequently, the instruments were randomly divided into 4 subgroups of 12 instruments each, depending on which movement was selected on the torque-controlled endodontic motor used (Silver Reciproc; VDW). In group 1, Reciproc R25 instruments were activated by using the program Reciproc ALL (RR), because these instruments were designed to be used in this way; in group 2, Reciproc R25 instruments were activated by using the program WaveOne ALL (RW); in group 3, WaveOne Primary instruments were activated by using the program Reciproc ALL (WR); and in group 4, WaveOne Primary instruments were activated by using the program WaveOne ALL (WW), which is their proprietary movement. All the instruments were activated by using a 6:1 reduction handpiece (Sirona Dental Systems GmbH, Bensheim, Germany).

To eliminate variability caused by possible different mechanical characteristics of dentin specimens, special Plexiglas plates (30 × 30 × 1 mm) created from the same original raw material were used. Each instrument was used only once, whereas each plastic block was used to test 1 instrument from each of the 4 groups tested; thus, 12 blocks were used. Cutting efficiency of all instruments was determined by means of a specially designed testing device manufactured for this study (Fig. 1). It consisted of a main frame to which a mobile plastic support for the handpiece was connected and a stainless steel block containing the Plexiglas plate against which the cutting efficiency of the instruments was tested. The dental handpiece was mounted on a mobile device connected to a fixed weight that by gravity drove the horizontal instrument against the Plexiglas block in a precise and reproducible way (Fig. 1). The same 150-g weight was used to test all instruments. To prevent the instruments from slipping out the smooth surface of the plastic, a notch 1 mm in depth and width was created on the lateral wall of the Plexiglas plate that measured 1 mm in thickness. The plastic support for the handpiece allowed for precise and simple 3-dimensional alignment and positioning of the instrument as soon as it came perpendicularly into contact with the notch created on the wall of the Plexiglas specimen without bending. The cutting efficiency was tested 14 mm from the tip of the instruments to avoid their deflection when the weight was applied nearer to the tip, as reported in a pilot study. Furthermore, the coronal blades of Reciproc instruments at 15–16 mm from the tip were sharper and deeper and did not permit the instrument to remain stable during the test. To permit removal of plastic debris created by the instrument during the test, an air compressor was attached and used during the entire experiment. Each instrument was tested in linear cutting unidirectional lateral motion, and the maximum penetration depth of the instruments was the criterion for cutting efficiency and the basis for the comparison as a function of time. In fact, the precise length of the plastic block cut in 1 minute was measured in millimeters for all groups tested by using a computerized program (Adobe Photoshop CS4; Adobe Systems, Santa Jose, CA) with a precision of 0.1 mm. The 1-mm notch was subtracted from the length obtained. Means and standard deviations of each group were calculated, and data were statistically analyzed for significant differences between group means with 1-way analysis of variance and Bonferroni *t* test, with the level of significance set at $P < .05$.

Results

For all groups, the mean maximum penetration depth and standard deviation are shown in Table 1. Reciproc R25 displayed significantly greater maximum penetration depth than WaveOne Primary for both movements used (RR group versus WR group and RW group versus WW group, $P < .05$); in particular, Reciproc instruments used with their proper reciprocating motion (group 1, RR) displayed statistically significant greater cutting efficiency than WaveOne instruments used with their proper reciprocating motion (group 4, WW) ($P < .05$). Although no statistical significance was present ($P > .05$), WaveOne ALL movement registered greater penetration depth than Reciproc ALL movement (RW group versus RR group and WW group versus WR group).

Discussion

This study compared the cutting efficiency of 2 M-wire NiTi reciprocating endodontic instruments chosen because of their similarities in size and manufacturing process. Reciproc R25 demonstrated a greater cutting efficiency than WaveOne Primary file, which could be explained by cross-sectional design and more positive cutting angle. The observation that instruments with S-shape cross section and 2 sharp cutting edges (Mtwo and Reciproc) were associated with an enhanced cutting efficiency was confirmed in previous studies (9–11, 21–26). Besides the cross-sectional design, the debris removal capability also determines the efficiency of mechanical instruments because the removal of cut dentin chips is important to reduce clogging of the cutting blades (1, 14). According to Camps and Pertot (27), Reciproc smaller cross section creates more space between the instrument and the canal walls, which might allow debris collection and removal capability (22). WaveOne larger triangular cross section might not provide enough space for debris to be displaced, thus reducing their cutting ability compared with Reciproc. Cutting efficiency and cleaning effectiveness of mechanical NiTi instruments are closely related (1), and recent studies reported that Reciproc instruments and instruments with S-shape cross-sectional design showed better canal cleanliness (22, 26, 28).

In this study, all instruments were operated under reciprocal cutting. Reciproc instruments were used with a reciprocating motion at a speed of 300 rpm and WaveOne at 350 rpm. The back-and-forth oscillation was 150° counterclockwise and 30° clockwise for Reciproc and 170° counterclockwise and 50° clockwise for WaveOne (20). The cutting efficiency improved as the movement speed increased, as demonstrated by the fact that both instruments displayed greater depth of penetration when used with the WaveOne ALL program, even without a statistically significant difference. However, this result allows no conclusions to be extrapolated clinically. In fact, manufacturers claim that the movement is precisely set on the mechanical characteristics of each specific instrument that must be used with the proprietary movement to be safe in clinical use and prevent torsional failure (http://www.vdw-dental.com/fileadmin/redaktion/downloads/presse/yared_reciproc_concept_en.pdf).

From the results of the present study, the cross-sectional design had a greater influence on the cutting efficiency than the movement

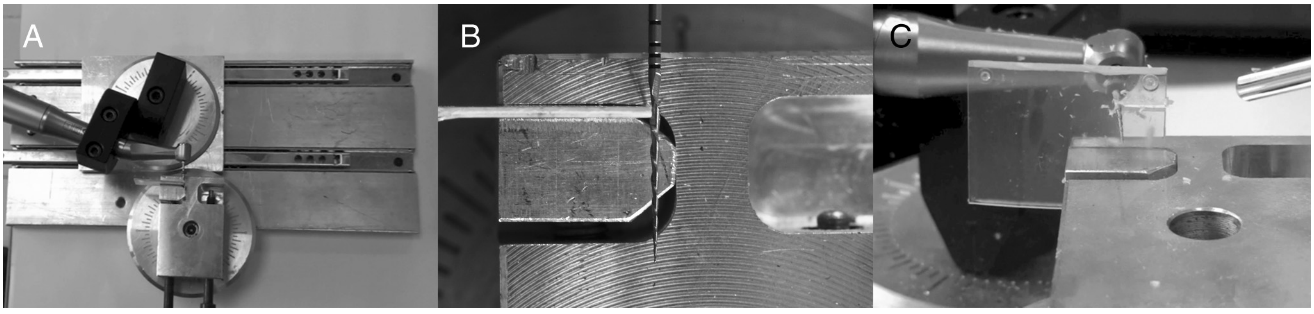

Figure 1. (*A*) The testing device specifically manufactured for the cutting test of the present study; (*B*) the instrument in contact with the Plexiglas block; (*C*) another view of the instrument while cutting the Plexiglas block.

TABLE 1. Cutting Depth

Group	RR	RW	WR	WW
Mean (mm)	8.5	9.1	6.7	7.4
Standard deviation (mm)	±0.4	±1.2	±0.7	±0.4

used. In fact, a greater difference was highlighted when different instruments were used with the same movement (RR group versus WR group and RW group versus WW group, difference 1.7 mm; $P < .05$) than when the same instrument was used with different movements (RR group versus RW group, difference 0.6 mm and WR group versus WW group, difference 0.7 mm; $P > .05$). Furthermore, in previous studies Reciproc instruments also demonstrated higher fatigue resistance than WaveOne instruments (29, 30), and angles of reciprocation influenced cyclic fatigue resistance of WaveOne instruments (31).

Even if clear standards for testing cutting effectiveness or sharpness of endodontic instruments have not yet been defined (1, 14), the use of a testing device in combination with special plastic samples guarantees standardized experimental conditions, allowing direct comparisons of the cutting ability of different instruments (9). In the present study, cutting efficiency of endodontic instruments was examined by operating them on plastic samples, because some studies discouraged testing with teeth because of their variable hardness and water content (8, 32). However, plastic does not exhibit the same properties as dentin, and the motion generated by the testing device did not reproduce the action of instrumenting a root canal, and further studies are required to correlate cutting efficiency with the quality of root canal preparation (33–35).

Nevertheless, according to the present results, Reciproc instruments demonstrated statistically higher cutting efficiency with respect to the WaveOne instruments. Cross-sectional design seemed to be a more decisive parameter than type of reciprocating movement concerning the cutting ability of NiTi instruments.

Acknowledgments

The authors deny any conflicts of interest related to this study.

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