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Analysis of cutting capacity, preparation time, and apical deviation after instrumentation of artificial curved canals with the waveone® and reciproc® reciprocating systems

Análise da capacidade de corte, tempo de prepare e desvio apical após a instrumentação de canais curvos artificiais com sistemas reciprocantes Waveone® e Reciproc®

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ABSTRACT

Objective
To analyze cutting capacity, preparation time, and occurrence of apical deviation, after instrumentation of curved canals with reciprocating Primary WaveOne® and R25 Reciproc® systems.

Methods
Twenty simulated canals with 35° bends were randomly assigned to the Primary WaveOne® or R25 Reciproc®. The preparations were made by a single operator. The cutting capacity was assessed by the difference in weight (on an analytical balance) of the canals before and after preparation. The time needed for the preparation was analyzed. The canals were filled with India ink and photographed on a platform before and after the preparation to analyze the apical deviation to a 1 mm length. The images were superimposed in Photoshop® and the measurement was performed with the ruler tool. Statistical analysis was performed using Student's t-test. The level of significance was set at 5%.

Results
The WaveOne® Primary system was more effective (in terms of cutting capacity) but had a longer preparation time than the R25 Reciproc® instrument. Apical deviation was the only variable that did not significantly differ between the two systems.

Conclusion
The WaveOne® Primary had a higher cutting capacity than the R25 Reciproc®. Both systems maintained the original canal path. The preparation time was shorter for the R25 Reciproc® than the WaveOne® Primary system.

Indexing terms: *Endodontics. Root canal preparation. Physical properties. Time. Dental equipment. Nitinol.*

RESUMO

Objetivo
Analisar a capacidade de corte, o tempo de preparo e a ocorrência de desvio apical, após a instrumentação de canais curvos com os sistemas reciprocantes WaveOne® e Reciproc®.

Métodos
Vinte canais simulados, com 35° de curvatura, foram randomicamente divididos para os dois sistemas. Os instrumentos utilizados foram o WaveOne® *Primary* e o R25 Reciproc®. Cada instrumento foi utilizado em um canal. Os preparos foram feitos por um único operador. Para análise da capacidade de corte, os canais foram pesados em balança analítica antes e após o preparo. A diferença na pesagem foi utilizada para aferição. O tempo para execução do preparo foi cronometrado e os valores obtidos foram analisados. Já para análise do desvio a 1 mm do comprimento de trabalho, antes e após o preparo, os canais foram preenchidos com tinta nanquim e fotografados em uma plataforma. As imagens foram sobrepostas no Photoshop® e, com a ferramenta régua, foi realizada a medição.

Resultados
Para análise estatística foi utilizado o teste T de *Student*, com nível de significância de 5%. Na análise da capacidade de corte, o sistema WaveOne® *Primary* foi mais eficaz que o instrumento R25 Reciproc®, embora o seu tempo de preparo tenha sido maior. Apenas no critério, desvio apical, não se verificou diferença significativa entre os dois sistemas.

Conclusão
O WaveOne® *Primary* apresentou uma maior capacidade de corte que o R25 Reciproc®. Ambos os sistemas respeitaram a trajetória original do canal. O tempo de preparo do R25 Reciproc® foi menor que o WaveOne® *Primary*.

Termos de indexação: Endodontia. Preparo de canal radicular. Propriedades físicas. Tempo. Equipamentos odontológicos. Nitinol.

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INTRODUCTION

The proper cleaning, disinfection, and shaping of the root canal system are one of the most challenging goals in endodontic treatment. The anatomical characteristics of root canals - such as moderate curvatures and lacerations, physiological or pathological mineralization, and variable diameter along the root path - make the procedure difficult and require greater caution, skill, and technical expertise from the professional.

The use of continuous rotation instruments during preparation has minimized the effects of these anatomical differences. It is more important that the path of the root canal be preserved when compared to manual preparation, performed with stainless steel instruments[1]. The risk of fracture and concern regarding the reuse of newer instruments persists[2].

With the goal of simplifying the preparation and increasing safety, in 2008, Yared[3] reported the different preparation that only used one instrument, Finishing File no. 2 (F2) (Universal Protaper®) system. This novel concept inspired the industry to develop new instruments, predominantly reciprocating systems. According to De Deus et al.[4], the use of "single use" instruments in reciprocating motion systems provides some advantages. Previous studies found that these advantages include shorter working time[5], lesser curvature learning[6], and lower risk of fracture within the channel[7].

This study investigated the cutting capacity, preparation time, and the occurrence of apical deviation after instrumentation of curved canals with two different reciprocating systems: WaveOne® and Reciproc®.

METHODS

Collection and preparation of simulated canals

Twenty simulated 16-mm-long canals (Dentsply Maillefer Instruments SA, Ballaigues, Switzerland) having a 35° curvature and 0.15-mm apex diameter were used.

During the preparations, the simulated canals were fixed in a clamp (Vonder®, Curitiba, Paraná, Brazil) to facilitate the implementation. The canals were laterally wrapped in foil (Wyda Packaging Industry Ltda., Sorocaba, São Paulo, Brazil) with only the notion of tilt direction of curvature, which was positioned in a standardized way, always facing the operator's right side.

The preparation of the canals was performed by a single operator who was trained to use the two systems. The instruments in both systems, WaveOne® Primary 25/8 (Dentsply Maillefer Instruments SA, Ballaigues, Switzerland) and Reciproc® R25-25/8 (VDW, Munich, Germany) were used for the preparation of a dummy canal.

Before the reciprocating systems were used, endodontic instrument type K no. 15 (Dentsply Maillefer Instruments SA, Ballaigues, Switzerland) was used manually to explore and advance dilate the path to be followed by the WaveOne® or Reciproc® instruments. The working length (WL) was standardized at 15 mm from the canal entrance.

During the procedure, the canals were filled with distilled water (Iodontosul - Dental South Industrial Ltda., Porto Alegre, Rio Grande do Sul, Brazil). An anionic detergent, Tergensol (Inodon, Porto Alegre, Rio Grande do Sul, Brazil) was applied to the reciprocating instruments for lubrication during insertion.

The endodontic instruments were powered by an electric motor VDW Silver (VDW GmbH, Munich, Germany). Prior to the procedure, the speed and torque were calibrated with the calibration function (CAL).

The instruments come in WL. Three consecutive pecking movements, ranging from 3 to 4 mm, were performed without removing the file from the simulated canal. This cycle of instrumentation was performed progressively in the cervical, middle and apical third of the canal, until mechanical preparation was finished.

Analysis of cutting efficiency

Each simulated canal was numbered and weighed on a very precise analytical balance (Ohaus Adventurer™, New Jersey, USA) to assess the cutting efficiency of the instruments. This weighing was performed before and after completion of the preparation.

After preparation, the simulated canal was irrigated and the solution was aspirated. Immediately afterwards, absorbent paper points no. 25 (Dentsply Maillefer Instruments SA, Ballaigues, Switzerland) were used to completely dry the canal and the final weight of the simulated canal was measured. The difference between the initial and final weight of the simulated canal estimated the cutting ability for the preparation.

Preparation time measurement

A digital timer (Herweg®, Timbo, Santa Catarina, Brazil) was used to measure the time required for the completion of the preparation. The start time was the time that the reciprocating instrument was placed into

the simulated canal. The stop time was the time when the canal was properly prepared.

Analysis of apical deviation

Before and after completion of the preparations, the simulated canals were placed on a platform in the same position and photographed with a digital camera D3200 (Nikon Corporation, Nagoyashi, Tokyo, Japan) from the same distance focal. To improve the contrast in the photographs, ink (Corfix, Porto Alegre, Rio Grande do Sul, Brazil) was injected into the simulated canals with a disposable syringe.

The images were manipulated in Adobe Photoshop, version 6.0. The images were transformed in millimeters using a rule of three, comparing the original size of the simulated canal with the image size on the computer screen. The sharpness of the images was retained and the number of pixels was not reduced the pixels.

Using the same program, the images were subjected to contrast adjustment. Each postoperative image was transformed into a layer with 50% transparency and superimposed onto the preoperative image.

The position to be analyzed was always in the same region and was 1 mm short of apical stop. The "ruler" tool in the Adobe Photoshop® software as used to locate the canal in the picture.

The offset value, measured using the "ruler" tool, was the distance from the point on the 1 mm WL on the opposite side wall to the canal bend area. The same canal position was measured before and after preparation (Figure 1).

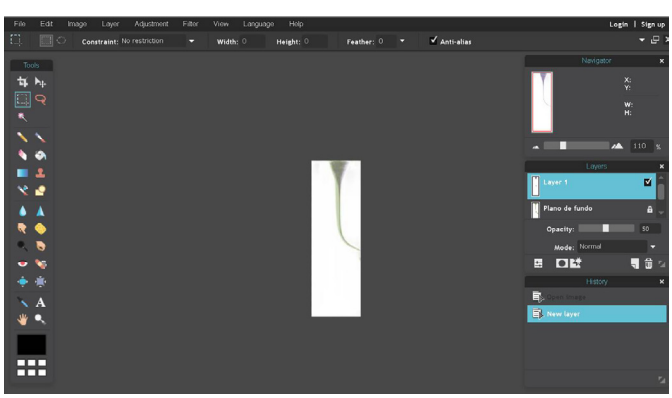

Figure 1. Analysis of apical deviation by overlapping images before and after the preparation of the simulated canal with the WaveOne® instrument.

Statistical analysis

Student's t-tests were used to compare the cutting capacity, preparation time, and apical deviation after instrumentation of curved canals with two reciprocating systems. The significance level was set at 5%. Statistical analysis was performed using SPSS, version 22.0 (SPSS Inc, Chicago, IL).

RESULTS

Table 1 shows the mean and standard deviation of the cutting capacity, the time to perform the preparation, and occurrence of apical deviation for the two reciprocating systems. The Primary 25/8 WaveOne® system had a greater cutting capacity than the R25 Reciproc® (P <0.001). The time required for the preparation was shorter for the Reciproc® system, compared with the WaveOne® (P <0.001). The apical deviation analysis showed no significant difference between the two reciprocating instruments (P=1.000). The average deviation was 0.032 mm.

Table 1. Mean and standard deviation of the cutting capacity, time to perform the preparation, and occurrence of apical deviation for the two reciprocating systems.

Analyzed Factors	Experimental group				P
	WaveOne®		Reciproc®		
	Mean	SD	Mean	SD	
Cutting capacity (grams)	0.024^{A}	± 0.008	0.011^{B}	± 0.003	<0.001
Preparation time (seconds)	35.242^{A}	± 8.953	23.909^{B}	± 5.830	<0.001
Apical deviation (millimeter)	0.032^{A}	± 0.005	0.032^{A}	± 0.005	1.000

Note: Means followed by diferente capital letters in line differ significantly by Student's t-tests, at a significance level of 5%.

DISCUSSION

There has been an increase in the availability of endodontic reciprocating instruments with different designs (WaveOne® (Dentsply Maillefer - United States), Reciproc® (VDW - Alemanha), Unicone® (Medin - Czech), and ProDesign Logic® (Easy - Brazil)). Studies have been conducted to analyze their properties, such as cutting efficiency during preparation[8], preservation of the anatomical path of the root canal[9], instrumentation time[10], and production of dentin debris[11]. This study compared three factors (cutting capacity, preparation time, and occurrence of apical deviation) for preparation of canals with the WaveOne® and Reciproc® reciprocating systems.

The decision to use artificial canals was based on several studies in the literature[12-13]. This method allows for standardization in the hardness of the material, diameter, and bend in the simulated root canal, which would not be possible in samples of natural teeth.

The first variable analyzed in the study was the cutting capacity of the two instruments during preparation. The Primary 25/8 WaveOne® system was more effective than the R25 Reciproc®. The WaveOne® has a section that varies along the instrument axis, where the middle part and closer to the handle is triangular, with convex sides and the region closest to the tip of this triangle is more concave. This instrument features three cutting blades, unlike the Reciproc®, that has only two. The R25 Reciproc® has an S-shaped cross-section around its axis[14]. There are some consistencies with these results and those obtained from other studies. Although Jeon et al.[15] and Saber et al.[16] did not find significant differences between the two reciprocating systems, Plotinus et al.[17], observed a higher cutting efficiency to Reciproc® R25 in relative Primary WaveOne®. In the study by Bürklein et al.[18], the R25 Reciproc® was better at cleaning the apical third of the root canal compared to the Finishing File no. 3 (F3) and the Primary 25/8 WaveOne®.

With respect to the preparation runtime, R25 instrument required less time to perform instrumentation of the WaveOne® Primary as well as in studies Bürklein et al.[18] and Saber et al.[16]. On the other hand, Park et al.[19] and Tongfei et al.[20] observed that the preparation was faster with WaveOne® system.

Vahid et al.[21] observed that the type of cross-section of mechanized tools can be a variable, which affects the time needed for the job. The same authors found that the continuous rotation instrument, Mtwo®, allowed for more rapid preparation than the ProTaper® universal tool, due to its "S" shape, which resulted in a much more aggressive cutting angle. For these instruments, even the continuous rotational motion is different than the alternating reciprocating motion. It is noteworthy that the Reciproc® system has the same section as the Mtwo® instrument and the WaveOne® relative to ProTaper® universal, which may explain the differences between the studies.

In the correlation between the two factors analyzed above, cutting capacity and preparation runtime, it is believed that the higher cutting capacity observed in the WaveOne® may have occurred due to the influence of the longer time of operation of the instrument within the simulated canal when compared to Reciproc®.

Both reciprocating systems respected the original path of the simulated canal, as was observed in studies by Gergi et al.[22], Alattar et al.[23], and Coelho et al.[24]. Silva et al.[25] reported that the Reciproc® instrument causes minor changes in the geometric conditions of the root canal during the preparation than WaveOne®. According to Tongfei et al.[20], the Reciproc® has a greater capacity centering the apical third of the root canal, while the WaveOne® instrument exhibits this property in the middle third of the canal.

CONCLUSION

According to the results of this study, it can be concluded that the Primary 25/8 WaveOne® system has greater cutting capacity than the R25 Reciproc® instrument; the R25 Reciproc® instrument performed the task faster than the Primary 25/8 WaveOne® system and the tested systems promoted similar apical deviation.

Collaborators

J BRUSCHI, main author of the paper. This article is part of your Cour-se Completion Work. Participated in all stages of the work. LB BOFF, coauthor of work. Helped and participated in the accom-plishment of all the experimental stages of the work. Participated in the review of the written part of the article. TAF MELO, is a endodontics teacher. He was coauthor and adviser of the students in the development and preparation of the Course Completion Work. Participated in the orientation, execution of the experiment and the writing of the article.

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