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# Wizard CD Plus and ProTaper Universal: analysis of apical transportation using new software

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## ABSTRACT

Objective: This study has two aims: 1) to evaluate the apical transportation of the Wizard CD Plus and ProTaper Universal after preparation of simulated root canals; 2) to compare, with Adobe Photoshop, the ability of a new software (Regeemy) in superposing and subtracting images. Material and Methods: Twenty five simulated root canals in acrylic-resin blocks (with 20° curvature) underwent cone beam computed tomography before and after preparation with the rotary systems (70 kVp, 4 mA, 10 s and with the 8×8 cm FoV selection). Canals were prepared up to F2 (ProTaper) and 24.04 (Wizard CD Plus) instruments and the working length was established to 15 mm. The tomographic images were imported into iCAT Vision software and CorelDraw for standardization. The superposition of pre- and post-instrumentation images from both systems was performed using Regeemy and Adobe Photoshop. The apical transportation was measured in millimetres using Image J. Five acrylic resin blocks were used to validate the superposition achieved by the software. Student's t-test for independent samples was used to evaluate the apical transportation achieved by the rotary systems using each software individually. Student's t-test for paired samples was used to compare the ability of each software in superposing and subtracting images from one rotary system *per* time. Results: The values obtained with Regeemy and Adobe Photoshop were similar to rotary systems ($P>0.05$). ProTaper Universal and Wizard CD Plus promoted similar apical transportation regardless of the software used for image's superposition and subtraction ($P>0.05$). Conclusion: Wizard CD Plus and ProTaper Universal promoted little apical transportation. Regeemy consists in a feasible software to superpose and subtract images and appears to be an alternative to Adobe Photoshop.

**Keywords:** Endodontics. Cone-beam computed tomography. Root canal preparation. Tooth apex.

## INTRODUCTION

Endodontic treatment aims to disinfect and to shape the root canals in order to make easy the irrigation procedures and the placement of root canal dressing of filling material[9]. The preservation of the radicular anatomy is one of the most important concerns during root canal preparation. Some enlargement techniques have been developed to minimize errors, such as ledging, zipping, loss of working length, and apical transportation[18]. Apical transportation is defined as the removal of canal wall structure on the outside curve in the apical half of the canal due to the tendency of files to restore themselves to their original linear shape during canal preparation[3].

The use of rotary nickel-titanium (NiTi) instruments allows easier and safer root canal

shaping with predictable results. Moreover, there is less iatrogenic damage even in severely curved root canals[18]. However, complete instrumentation of the root canals is critical especially at the apical third[1]. Rödig and Kahlmeier[19] (2007) stated that in curved canals the instruments tend to straighten the root canal owing to the major cutting effect toward the inner aspect of the curvature at the cervical root third and toward the outer aspect of the curvature at the root canal end point. Previous reports had pointed that NiTi instruments tend to be more centered, rapid, and attain a more conservative shaping of canals than stainless steel instruments[13]. Especially the centering ability of NiTi instruments is owed to their super elastic behavior and shape-memory, even though apical transportation occurs even when super elastic instruments are used.

Several reports about apical transportation have been published regarding ProTaper Universal instruments (Dentsply Maillefer, Ballaigues, Switzerland)[9,12,24]; however, there are few reports regarding Wizard CD Plus (Medin, Prague, Czech Republic). According to the manufacturers, Wizard CD Plus instruments present a triangular cross section, with no surface treatment, a working part taper ratio of 10%, 8%, 6%, 4% and 2%, and cutting edges discontinued by grooves in the helix, which were intended for machine preparation of root canals by means of the crown-down method. ProTaper Universal system has triangular convex cross section and three cutting edges with a negative cutting angle[24]. The shaping instruments have a progressive taper sequence (increasing from tip to coronal), whereas the finishing instruments have a decreasing taper profile. It is claimed that the progressive taper sequence will enhance the flexibility of the files in the middle and at the tip region, and that the decreasing taper sequence will enhance the strength of the files while making them rather stiff[4].

In Endodontics, apical transportation is evaluated after superposition and subtraction of two images (i.e., pre-operative and post-operative images)[2,11,22]. AutoCad[22] and Adobe Photoshop (Adobe Systems Inc, San Jose, USA)[9,11] are currently used for this purpose; however, the main disadvantage of the AutoCad and Adobe Photoshop is that both need manual superimposition of the images which depends on the operator.

In the beginning of the 2000s, the Brazilian National Institute for Space Research in partnership with the Electrical and Computer Engineering Department from University of California developed a computer program for mapping the Earth through satellite images. Initially, it was developed for detecting areas of deforestation along the years. This software is called Regeemy - Image Registration and Mosaicking, Version 0.2.43 can be downloaded from the Internet for free (http://regima.dpi.inpe.br/download.html). This program automatically selects pixels of the same tone in two images and superposes them. Up to date, only one study used the Regeemy program to superpose images in Dentistry[16]. The authors evaluated the ability of the program in detecting simulated external root resorption.

In the endodontic context, the ability of Regeemy in superposing and subtracting tomographic or radiographic images is unknown. Thus, the aims of this study were: (1) to evaluate the apical transportation of the Wizard CD Plus and ProTaper Universal after preparation of simulated root canals; (2) to compare, with Adobe Photoshop, the ability of a new software (Regeemy) in superposing and subtracting images. The hypotheses were: (1) that Wizard CD Plus and ProTaper Universal would promote similar apical transportation; and (2) Regeemy would permit the superposition and subtraction of images.

## MATERIAL AND METHODS

Twenty-five simulated root canals made of clear resin (Endo Training Block; Dentsply Maillefer, Ballaigues, Switzerland) with an initial .02 taper, 0.15 mm diameter at the apex and 20° curvature were divided into two groups according to the rotary system (10 specimens *per* group) and one control group (n=5). Every working length was established to 15 mm (1 mm shorter than the apex) by inserting a size 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) into the simulated root canal. Thereafter, the samples had previously been numbered and properly positioned in devices made of acrylic resin and, with the file in position, a cone beam computed tomography (CBCT) (iCAT Cone Beam, Hatfield, USA) was carried out. All CBCT was acquired with the same setting at 70 kVp, 4 mA, 10 s and with the 8×8 cm field of view (FoV) selection. The data set consisted of axial, sagittal and coronal reconstructions; the size of the reconstructed voxels was 0.16 mm. Images were saved on a computer for further evaluation and comparison.

In control group, the specimens were subjected to a new CBCT under identical conditions to assess the feasibility of the software (Regeemy and Adobe Photoshop) in superposing and subtracting both tomographic images.

Simulated root canals in experimental groups were instrumented by the same operator, who was previously calibrated to each one of techniques described below. The resin blocks were mounted on a vise (Neboluz, São Paulo, Brazil) that kept them fixed, without allowing the operator to see the instruments inside the simulated canals.

ProTaper group was prepared with the ProTaper Universal System using the SX and S1 instruments for preparing the cervical third, followed by the S2 instrument in the middle third. A paint-brush movement was used with the S series instruments. The F1 and F2 instruments were later used at the working length, and each instrument was used in a uniform and continuous motion without applying pressure. Wizard CD Plus group was prepared using this system through the crown-down technique, with input motion, light apical pressure and anti-curvature pressure. A 25.7 and a 30.6 file were used in the middle third. Next, a 25.4 file was used in middle third and the beginning of the apical third and finally 20.04 and 25.04 files were used in full working length. After each instrument change, a size 10 K-file was inserted up to the entire working length and the canal was irrigated with 1 mL of 2% sodium hypochlorite. Each instrument was used in three acrylic resin blocks and then discarded.

An Endo Pro Torque (VK Driller Equipamentos Elétricos Ltd., Jaguaré, Brazil) electric motor was used for simulated root canals preparation, at a speed of 250 rpm with a torque of 2 N.cm. After canal preparation, the acrylic blocks underwent a second CBCT scan under the preoperative conditions as described previously.

### Image standardization

The tomographic images from the simulated canals were edited in the iCAT® Vision and CorelDraw® software for precise standardization of the position of the acrylic resin block with regard to the X and Y axes.

### Image subtraction

The subtraction of post-instrumentation and pre-instrumentation CBCT images of the acrylic-resin blocks was performed using the Regeemy and Adobe Photoshop software according to their tutorials. Once the final images were obtained (pre-instrumentation plus post-instrumentation image), they were saved in .tiff format.

### Apical transportation analysis

The tips of the files in subtracted images were analysed using ImageJ software (National Institutes of Health, Bethesda, USA) under 25% magnification. The scale was calibrated using the bottom of the acrylic resin block (10 mm) as reference to convert pixels to millimetres.

A straight line was drawn joining the tip of the files in the subtracted images for measuring (Figure 1). This process was performed in all images and repeated three times at intervals of 48 hours, by one blinded examiner who had previously been calibrated to the measurement procedure.

### Statistical analysis

The kappa test was used to analyze the agreement between the readings of the examiner at different times. Shapiro-Wilk normality test was used to assess if the data adhere to a Gaussian distribution. Student's t-test for independent samples was used to compare the means of the apical deviations between the two groups. And finally, Student's t-test for paired samples was used to compare the ability of each software in superposing and subtracting images from one rotary system *per* time. The significance level was set at 0.05.

## RESULTS

The intra-examiner agreement after three readings was 0.76. The Regeemy software provided the subtraction of the pre- and post-instrumentation tomographic images of the acrylic blocks, allowing

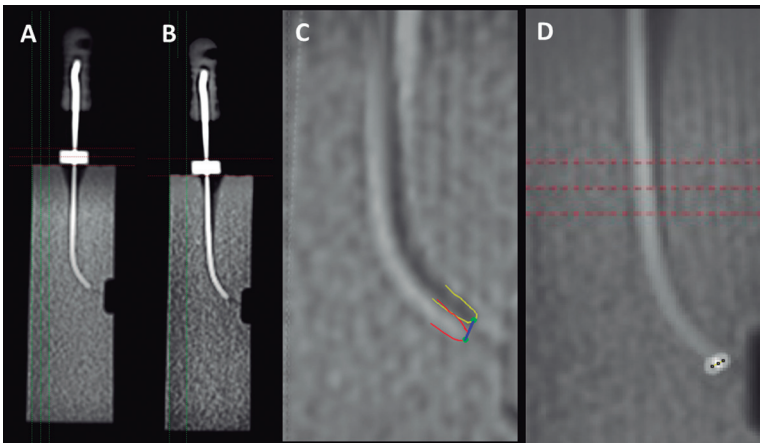


**Figure 1-** Exemples of the method used to assess the apical transportation. A) Pre-instrumentation image; B) Post-instrumentation image; C) Regeemy: the tip of the files was delimitated and a straight line was drawn joining both tips (black: file in the pre-instrumentation image; white: file in the post-instrumentation image); and D) Adobe Photoshop: white points indicated the files' tips in both images and then a straight line was drawn to join these points

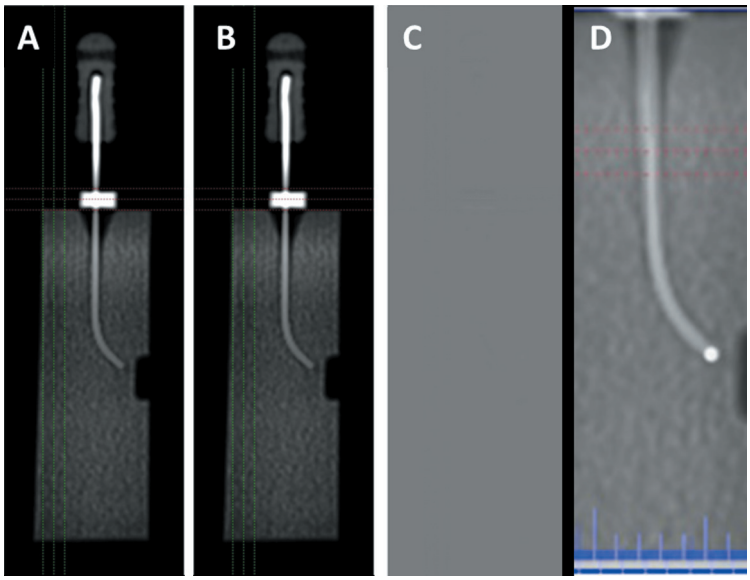


**Figure 2-** A and B) In control group, five specimens were subjected to two CBCT under identical conditions; C) Result of a superposition and subtraction using Regeemy (Note the intermediate gray levels); and D) Result of a superposition and subtraction using Adobe Photoshop (Note the coincidence of the tips of the files in the final image)

**Table 1-** Means, standard deviations and confidence intervals of apical transportation after using the two rotary systems and both software

| Software | Groups | Mean | Standard Deviation (±) | Lower 95% CI | Upper 95% CI |
|---|---|---|---|---|---|
| | Protaper | 0.46[A] mm | 0.16 mm | 0.35 mm | 0.58 mm |
| Regeemy | | | | | |
| | Wizard CD Plus | 0.44[A] mm | 0.25 mm | 0.26 mm | 0.62 mm |
| | | | | | |
| | Protaper | 0.42[A] mm | 0.28 mm | 0.0 mm | 1.02 mm |
| Adobe Photoshop | | | | | |
| | Wizard CD Plus | 0.48[A] mm | 0.22 mm | 0.0 mm | 0.91 mm |

The Student's t-test did not reveal any significant difference between the experimental groups (P>0.05)

the analysis of apical transportation using ProTaper Universal and Wizard CD Plus systems. In control group, apical transportation did not occur (Figures 2A and 2B). The entire final image presented intermediate gray levels (128 grayscale value) when Regeemy was used (Figure 2C). Figure 2D shows the coincidence of the tips of the files in pre- and post-operative images when Adobe Photoshop was used. The Student's t-test did not reveal any difference between the experimental groups (P>0.05). Wizard CD Plus and ProTaper Universal presented few apical transportation regardless of the software used for image superimposition and subtraction (P>0.05) (Table 1). The values of apical transportations achieved using the Regeemy were similar to those obtained using Adobe Photoshop (P>0.05).

## DISCUSSION

Both acrylic resin blocks and extracted human teeth are used for apical transportation analysis. Extracted human teeth provide similar conditions to the clinical situation when compared with acrylic resin blocks. Moreover, they present actual surface texture, hardness and cross-sectioning dentin areas[5]. However, natural teeth present variation in morphology which impairs the comparison of the experimental groups[9]. On the other hand, acrylic resin blocks allow the observation of the preparation in three dimensions along the whole canal length and a direct comparison of the shaping ability of different instruments[14]. In addition, they provide standardized length, diameter and angle of curvature of the simulated root canals[9,23]. From a statistical point of view, the standard deviation might increase whenever a range of curvatures is

used, as opposed to the use of standardized acrylic resin blocks where this problem is minimized[22]. The uses of acrylic resin blocks facilitate the evaluation of the feasibility of the Regeemy in comparison with Adobe Photoshop in superposing and subtracting images. However, owned to the difference between materials nature (i.e. acrylic resin and dentin), care should be taken in the extrapolation of these findings to clinical use where dentine is involved.

Both rotary systems promoted similar apical deviation after preparation of the simulated root canals (P>0.05). Therefore, the first hypothesis was confirmed. Similar to other studies that have compared different rotary Ni-Ti systems regarding the apical transportation, the present study did not detect significant differences between the ProTaper and Wizard CD systems[8,12,15,20,22]. Good flexibility and the centralizing ability of root preparation by the F2 (ProTaper) and 25.04 files (Wizard CD Plus) likely contributed to the small and similar apical transportation values.

Different cross-sectional geometries of rotary instruments are believed to increase cutting efficiency, consequently reducing contact areas and torsional loads[2]. It is also known that the mass of the instrument plays an important role on the centering ability of these instruments. ProTaper Universal presents multiple tapers over the length of their cutting blades. It also presents a triangular convex cross section with shallow U-shaped grooves. All these features try to improve the flexibility of the larger instruments[2]. Despite presenting the same taper along the entire cutting blades, Wizard CD Plus promoted similar apical transportation in comparison with ProTaper Universal. Thus, continuous and multiple tapers did not influence the apical transportation in simulated root canals.

The findings regarding Wizard CD Plus are scarce. Up to date, only one study evaluated this rotary system[6]. The findings of the present study agree with those published in a master's dissertation in the year of 2012[6]. Apical transportation occurred in all groups. Moreover, the authors did not find differences regarding the apical transportation between Wizard CD Plus and other two rotary systems (ProTaper and Wizard Navigator). The author stated that irregularities in Wizard CD Plus surface may have contributed with a poor standardization of centering ability, which was corroborated by the high standard deviations observed. The same did not occur in this study, in which Wizard CD Plus' standard deviation was similar to that observed in the ProTaper group[6]. According to Grazziotin-Soares, et al.[10] (2011), ProTaper instruments present lower flexibility after the third use. Thus, in order to avoid apical transportation originating from repeated preparation, each instrument was used in only three acrylic resin blocks and then discarded.

Regardless of the final instrumentation size, the risk of transportation always increases in curved canals with an increase of file size[23]. Schafer and Vlassis[21] (2004) stated that ProTaper may induce apical transportation towards the outer aspect of the root canal especially because of the progressive tapers along the cutting surface of these instruments. The decreasing taper sequence of the finishing files enhances the strength of the files, but it increases the stiffness of their tip[21]. On that basis, in this study the canal preparation was performed up to F2 instrument in ProTaper group. Other reason for using F2 instruments was to permit direct comparison with Wizard CD Plus size 25.04, which has similar mass and identical diameter of the tip. Wizard CD Plus is a new rotary system and due to that there are no studies related to its behavior regarding cyclic fatigue and number of uses. Closing partially this gap, Wizard CD Plus seems to promote similar apical deviation when compared with ProTaper files in acrylic resin blocks. However, further investigations are needed to secure a better indication of its use in clinical practice.

Clinically, it seems questionable whether these comparably small values in apical transportation have any clinical significance. Anyway, the apical transportation values for the two systems are believed to be reliable because of the comparison of a new software with a current one (Adobe Photoshop) to superpose and subtract images. The Student's t-test for paired samples revealed that the readings performed by each software were similar (P>0.05). Thus, the second hypothesis was confirmed.

The subtraction of one image from another requires superposing these images in order to analyze the differences that have occurred over time. Even small differences can be visualized through image subtraction methods and programs[17]. Regeemy software subtracts the structures that have not changed between two radiographic/tomographic images pixel by pixel, resulting in a third image that is surrounded by a neutral gray background with grayscale values of approximately 128 for the unchanged areas. Patchy areas in the pre- and post-operative images are conventionally shown by a dark-gray shade or black (with grayscale values approaching zero) and by a light-gray tone or white (with grayscale values close to 255)[7]. Adobe Photoshop transforms each image to 50% transparency. However, the process of superposition must be performed manually with the post-instrumentation image separately positioned over the pre-instrumentation image. This is the main disadvantage of Adobe Photoshop. Images

must be aligned manually and this process may be influenced by the operator. To avoid this drawback, the present study performed three superposition processes and three readings *per* resin block in both software. Therefore, the readings achieved using Regeemy and Adobe Photoshop were similar for the rotary systems.

The effectiveness of the software in superposing and subtracting pre- and post-instrumentation images was confirmed by the control group. All the specimens from the control group were exactly superposed. After the subtraction process using Regeemy the final images were always with a 128 grayscale value. These values indicate that no apical transportation occurred. When Adobe Photoshop was used, the accuracy of the superposition process was assessed after marking the tip of the file in each image. If the points were coincident at the final image, then the superpose process was correct. The inclusion of a control group aimed to validate the methods for superimposition and subtraction of the CBCT images from the experimental groups.

Besides being originally developed to map the deforestation in native areas, Regeemy was used for the first time in Dentistry in 2005[7]. This software has proven to be an alternative technique to current ones for subtracting radiographic/tomographic images. It reduces the variation of gray levels in the subtracted image, indicating that the software superposes the pre- and post-operative images more accurately than *a priori* tools (i.e., film, phosphor plates, radiographic film holders)[7]. In addition, six years later, Ono, et al.[16] (2011) used this software to correct geometric discrepancies and equalize the contrast of two sequential radiographs before the use of the digital subtraction technique in cases of simulated root resorption.

The main difficulty that occurs when working with Adobe Photoshop is that this software is not widely available because they are limited to institutions or are too expensive to be easily purchased. Regeemy closes this gap because it is a program that can be downloaded for free upon registration with the DPI-INPE. This program provides the necessary support for research because it performs superimposition, subtraction and geometric correction of images by automatically marking multiple control points with the same software[7]. Moreover, it allows a practical and simple process, with few variations, and costless[7].

## CONCLUSIONS

Two conclusions can be drawn: (1) Wizard CD Plus and ProTaper Universal systems promoted slight and similar apical transportation after the preparation of simulated canals; (2) Regeemy consists in a feasible software to superpose and subtract images and appears to be an alternative to Adobe Photoshop.

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