EVALUATION OF THE TIME AND EFFICIENCY OF TRUNATOMY, VDW.ROTATE, PROTAPER GOLD AND RECIPROC BLUE IN SHAPING ROOT CANALS - AN IN VITRO STUDY

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ABSTRACT

Aim of the study To analyse and compare on extracted teeth the shaping time and the modifications of the root canal contour by using four different nickel-titanium mechanical systems. Material and methods Four groups, each of 6 human single-rooted teeth, were shaped using TruNatomy (Dentsply Sirona Maillefer), VDW.ROTATE (VDW), ProTaper Gold (Dentsply Sirona) or Reciproc blue 25 (VDW) and the shaping time was digitally recorded. Initial and final cone beam computed tomography (CBCT) images were taken and the same cross-section of each sample was analyzed in Image J program to measure the initial area of the root canal, before shaping, and the final area, after the use of each system. Differences between final and initial area were calculated and a statistical analysis was performed. Results The amount of tooth structure removed was minimum for VDW.ROTATE and TruNatomy, as expected. Also, TruNatomy recorded the shortest shaping time, with a mean of 14.05s/canal, significantly different from all the other systems. Conclusions Nickel-titanium shaping systems with reduced taper and fewer instruments are more conservative and efficient in root canal shaping.

Keywords:
Root canal preparation, Nickel-titanium instruments, Cone-Beam Computed Tomography, TruNatomy, VDW.ROTATE

INTRODUCTION

The proper cleaning, widening and shaping of the root canal anatomy by using hand or rotary instruments in association with specific irrigation protocols ensures the long-term success of endodontic therapy [1, 2]. Nickel-titanium (NiTi) rotary systems are mostly used nowadays for this purpose due to their shaping ability and the possibility to obtain faster preparations without deviations [2-4]. Over the years, the 360° clockwise rotational movement of NiTi files has changed

and instruments working in a clockwise and counter-clockwise rotation with different angles (reciprocation) have been developed [5-7].

Not only the specific movement of the instruments has changed over the years, but also many improvements have been made in their cutting ability and flexibility due to their modified cross-sections and to the different treatments of the classical NiTi alloy [8, 9]. Two new rotary systems were launched in 2019 with new design, flexibility and material, dedicated for more conservative approach in access cavity and root canal shaping [10-13]. The new heat-treatment of the nickel-titanium alloy in VDW's VDW.ROTATE and Dentsply's TruNatomy increases the flexibility of the cutting files without compromising their efficiency [10-13].

TruNatomy (TRN) (Dentsply Sirona Maillefer, Ballaigues, Switzerland) contains three shaping instruments in three different sizes: Small (20/.04), Prime (26/.04) and Medium (36/.03) with an off-centred parallelogram cross-section design and two initial files, an orifice modifier TRN OM (20/.08 taper) and a glide-path file TRN Glider (17/.02) [10-12]. Instead of 1.2 mm of other rotary NiTi systems, the wire design of TruNatomy has only 0.8 mm. They all have shorter handle of 9.5 mm to improve the straight-line access and placement of the instruments into the root canal [10-12]. Due to the regressive tapers, slim design and instrument geometry, TruNatomy instruments preserve the structural dentine and tooth integrity, but there is no data available on their fatigue resistance [10-12].

VDW.ROTATE (VDW GmbH, Munich, Germany) consists of three basic files with an adaptive S-shaped cross-section used in the preparation of narrow and highly curved canals including apical curvature (15/.04; 20/.05 and 25/.04) and other three for the majority of the clinical cases (15/.04; 20/.05 and 25/.06) [5]. The cyclic fatigue resistance and the lower risk of breakage of these files are given by the heat treatment of the NiTi [13].

In addition to the newest appearances on the market, "older" systems are still preferred by clinicians due to their proved efficiency in shaping root canals with good clinical results.

ProTaper Gold (Dentsply Sirona, Ballaigues, Switzerland) is a rotary system with a convex triangular cross-section composed of three shaping files and five finishing files. The shaping files are designed to be used with a brushing technique and to pre-enlarge the canals: SX (19/.04v), S1 (18/.02v), S2 (20/.04v) [14]. The finishing files: F1 (20/.07v), F2 (25/.08v), F3 (30/.09v), F4 (40/.06v) and F5 (50/.05v) are used to shape and finish each canal due to their flexibility [14]. ProTaper Gold has advanced metallurgy features that enhance their flexibility and resistance to cyclic fatigue [14, 15].

Reciproc Blue (VDW GmbH, Munich, Germany) is composed of three instruments with an S-shaped cross-section dedicated for narrow, medium or large canals: R25 (25/.08), R40 (40/.06) and R50 (50/.05) [6, 16]. Having the same geometry with the Reciproc (VDW) system, the main difference is represented by the innovative heat treatment of the NiTi alloy, which modifies its molecular structure to give the file increased resistance to cyclic fatigue and additional flexibility, as well as its characteristic blue color [5, 6, 16].

Aim of the study

The aim of the present study was to evaluate the efficiency in root canal preparation of these four nickel-titanium endodontic systems: ProTaper Gold

(Dentsply Sirona, Ballaigues, Switzerland), TruNatomy (Dentsply Sirona Maillefer, Ballaigues, Switzerland), VDW.ROTATE (VDW GmbH, Munich, Germany) and Reciproc blue (VDW GmbH, Munich, Germany) on human extracted monoradicular teeth with one root canal by comparing the time used for shaping with each system and the modifications of the root canal contour after shaping on cone beam computed tomography (CBCT) analysis.

MATERIALS AND METHODS

Twenty-seven recently extracted monoradicular human teeth, free of caries, restorations or endodontic treatment were initially selected for the present study. Teeth were fixed in a vertical position in a prefabricated silicone key (Zetaplus, Zhermack, Badia Polesine, Italy) and were radiologically evaluated by using cone beam computed tomography (CBCT) to confirm the presence of a single straight root canal in each tooth. After the initial CBCT analysis, only twenty-four samples proved to fulfill the selection criteria of having only one root canal and were included in the study. Minimally invasive access cavities were created on each tooth with a high-speed diamond bur and straight-line access was created. Working length was determined for each root canal using pre-curved stainless steel SSt #10 K-files (Dentsply Maillefer) and apical patency was confirmed for all root canals.

Samples were divided into 4 groups, each containing 6 samples (n=6) according to the mechanical NiTi system used for shaping: Group 1 - ProTaper Gold PTG (Dentsply Sirona, Ballaigues, Switzerland) with the instruments S1 (18/.02), S2 (20/.04 taper), F1 (20/.07 taper), F2 (25/.08 taper); Group 2 - TruNatomy TRN (Dentsply Sirona, Ballaigues, Switzerland) with the instruments TRN Orifice Modifier OM (20/.08 taper), TRN Glider (17/.02) and the shaping file TRN Prime (26/.04); Group 3 - Reciproc Blue (VDW GmbH, Munich, Germany) R25 (25/.08); Group 4 - VDW.ROTATE (VDW GmbH, Munich, Germany) with the Glide Path file 15/.04, and the shaping files 20/.05 and 25/.06.

The instruments were operated using the contra-angle hand piece of the X-Smart Plus endodontic motor (Dentsply Sirona, Ballaigues, Switzerland) with each specified speed and torque according to the manufacturer's instructions, respectively reciprocation setting (Function: Reciproc all) for the R25 blue instrument. For the ProTaper Gold system the speed used was 250 rpm and the torque varied between 1 Ncm and 2 Ncm depending on the file used. TruNatomy files were used at a speed of 500 rpm and a torque of 1.7 Ncm. VDW.ROTATE Glide Path files were used at a speed of 350 rpm and a torque of 1.3 Ncm. For VDW.ROTATE 20.05 and 25.06 shaping files, the speed of 400 rpm and the torque of 3.5 Ncm were used.

The same irrigation protocol was used during instrumentation for all shaping sequences: 2.5 % sodium hypochlorite solution NaOCl (Chloraxid, Cerkamed, Stalowa Wolla, Poland) alternating with ethylenediaminetetraacetic acid EDTA solution 17% (Endo-Solution, Cerkamed, Poland).

Shaping time analysis

The shaping time for each file and system was measured with a digital chronometer from the Samsung Galaxy S9 Plus smartphone (Samsung, Nguyen, Vietnam). The minimum and maximum value of the total shaping time for each system was recorded in a table; the mean values and the standard deviation

were calculated and comparisons between systems were made (Table 1).

CBCT-Area analysis

After shaping, teeth fixed in the same vertical position as initial were digitally radiographed for the final CBCT analysis. Initial and final cross-sectional areas were measured and compared on axial sections at the same level of investigation on the before and after CBCTs.

The CBCT images were analyzed using the CD Viewer.exe program with the "Print screen" function (PrtSc) used to capture the radiological image of each sample on the before and after CBCT. The "Paste" function was used to insert each image in the Paint application of the Microsoft Office program (Microsoft, Albuquerque, New Mexico, US). Images were analyzed in the ImageJ Program for each sample and using the Ctrl-E function the features of the images were changed to the same resolution: Width (pixels): 212; Height (pixels): 184. The "Oval" function was selected to encircle the contour of the root canal on the same level of each axial section of the before and after CBCTs (Figure 1), and the initial and final area in pixels were registered for each sample using the Analyze→Measure function. The area in pixels was converted into mm^2 by multiplying it with 0.00147.

The initial and final areas for each system were recorded in a new table and the differences between the final and the initial area were calculated by subtracting. The "=AVERAGE" function was used to determine the mean of the initial, final and the difference area. One-way ANOVA statistical analysis was performed to determine the differences between the initial and final area, with a p-value set at $p<0.05$ being statistically significant considered.

The minimum, maximum and mean values of the recorded shaping time, the initial, final and differences of area, and the results of the statistical analysis were recorded into one table, in order to be compared (Table 1).

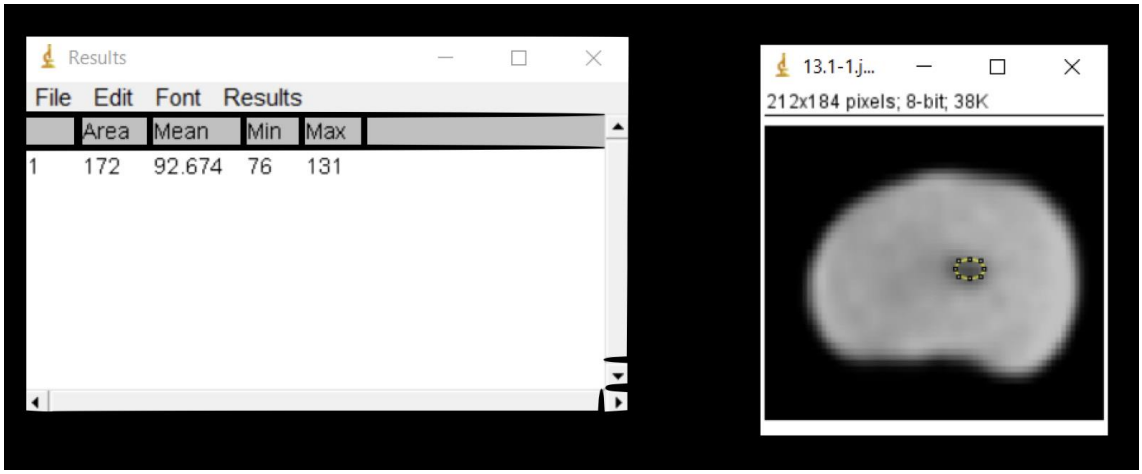

Figure 1. Area measurement on the CBCTs cross-sections using the Image J Program

RESULTS

Shaping time analysis

According to the collected data from the present study, the most efficient system regarding the total used shaping time was TruNatomy (Group 2 TRN-Table 1), with a mean total time of 14.05s, significant different from all the other systems.

VDW.ROTATE (Group 4 ROT-Table 1) registered more than double time than TRN (39.99s), but lower in comparison to R25 and PTG. For Reciproc Blue 25/.08 (Group 3 R25-Table 1), a higher mean-time value for shaping was measured (53.075s), but lower than for ProTaper Gold, with the longest shaping time (63.003s) (Group 1 PTG-Table 1).

As observed (Fig. 2), the total shaping time/canal needed for the TRN system varied between 7.3 and 31.67s, although for each canal three instruments were used until final shape was achieved. For Reciproc blue 25/.08 the time varied between 5.95 and 77.84s, but only one instrument was used. VDW.ROTATE (3 instruments) recorded a total shaping time between 8.18 s and 89.89s, while for ProTaper Gold (4 instruments) shaping time varied between 27.74 and 83.46s.

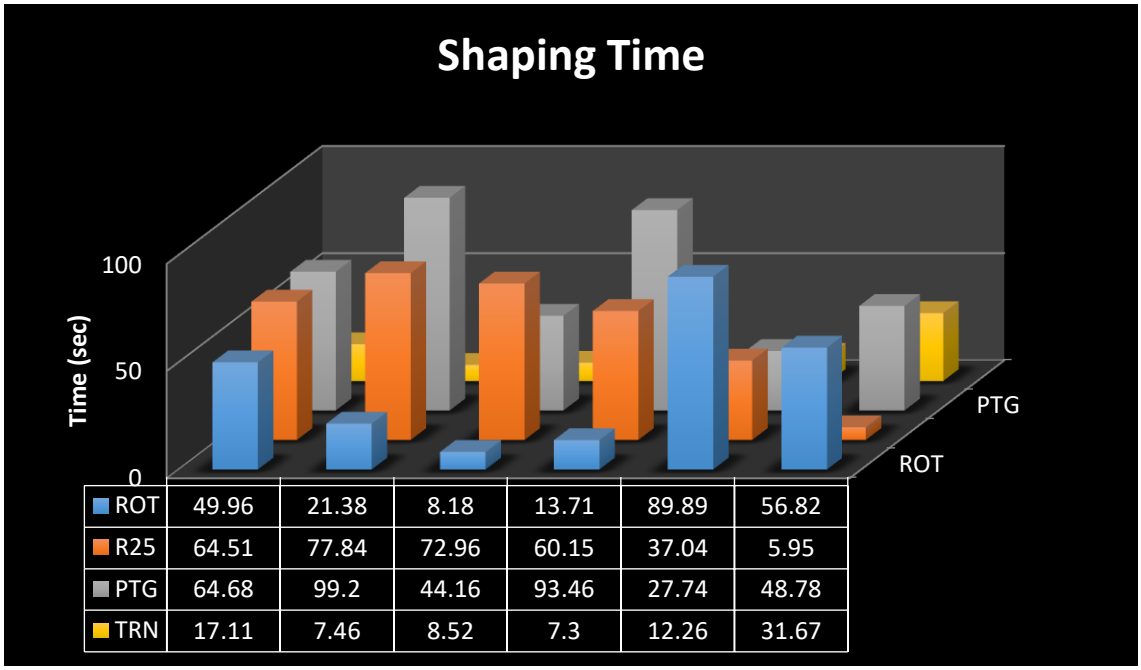

Figure 2. Comparison between the total shaping time/canal (s) for each system and sample

The fastest system as mean time values was TRN, although the lowest shaping time for one sample was achieved in a root canal from the Reciproc 25 Group, 5.95s, where only a single instrument was used. The longest shaping time for one sample was recorded for the PTG system, 93.46s. The use of four instruments in a sequence S1, S2, F1, F2 to achieve the same apical size as for the other systems (0.25 mm) necessitated a longer shaping time.

CBCT-Area analysis

The results for the initial and final measured areas on CBCTs and the differences recorded (mm^2) in the canal

size after shaping are presented in Table 1. It can be observed that the smallest increase of the root canal area on a specific level was obtained for the VDW.ROTATE system, 0.1035 mm^2, followed by TruNatomy, 0.137 mm^2.

The highest increase was recorded for ProTaper Gold (0.2565 mm^2) followed by Reciproc blue 25/.08 (0.162 mm^2).

As comparison, a graphic representation (Fig. 3) of the mean initial, final and difference area was used to highlight the shaping ability of each system. More conservative systems like TruNatomy and VDW.ROTATE recorded a smaller mean difference, proving less removal of the tooth substance and a more conservative shaping during the instrumentation step of the endodontic treatment.

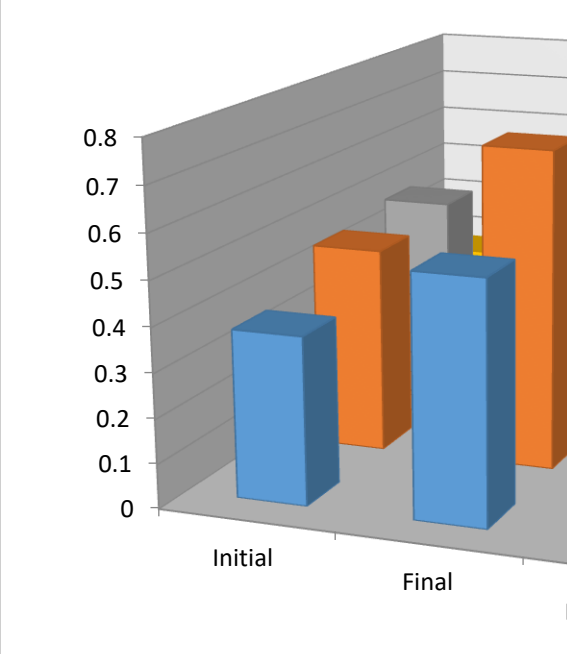

Figure 3. Comparison between the Mean values of the Initial, Final and Differences of Area for each Group

One-way ANOVA Statistical analysis

ANOVA Single Factor statistical analysis with a p-value less than 0.05 considered statistically different was performed to compare the groups as time and area. According to Table 1, no significant differences ($p>0.05$) between groups were observed for Area analysis, but a significant difference ($p<0.05$) was observed for the total shaping time when comparing the four systems.

DISCUSSIONS

Few comparisons were found in the literature between the two new recently launched NiTi rotary systems with conservative taper: VDW.ROTATE (VDW, Munich, Germany) and TruNatomy (Dentsply Sirona, Ballaigues, Switzerland) and other rotary or reciprocating systems [12, 17-19], and none, as the authors of the present study know, regarding their ability in root canal shaping time and tooth structure removal.

Because these new systems include a variety of files with smaller taper sizes and slim design, they allow the preparation of narrow root canals with a more conservative coronal and apical taper, being more protective with the root canal dentin [10-13]. As the present study showed, more conservative preparations were obtained when comparing these two new systems with Reciproc blue (VDW, Munich, Germany) and ProTaper Gold (Dentsply Sirona, Ballaigues, Switzerland), with VDW.ROTATE being more conservative than TRN. Also, both these systems proved to achieve final shapes of the root canal in minimum amount of time, with excellent results for TruNatomy, although the system includes a sequence of 3 files for shaping.

Because different types of heat treatments are used in the manufacturing process of these files, they also present the advantages of increased elasticity and resistance to cyclic fatigue [4-6]. Moreover, the study of Riyahi *et al.* (2020), in a comparison between TruNatomy, ProTaper Next (Dentsply Sirona) and Twisted Files (Sybron Endo, Orange, CA, USA), showed that TRN was more resistant to cyclic fatigue [17]. Another study comparing TruNatomy and HyFlex CM (Coltene Whaledent, Altstatten, Germany) files proved that both of the systems have an increased fatigue resistance [18]. The study of Uslu *et al* (2020) compared the VDW.ROTATE files with HyFlex CM instruments and concluded that no significant difference in cyclic fatigue was observed between these two systems [19].

In the present study, no file from the TRN system, VDW.ROTATE or any other system used in the shaping of the samples fractured, regardless the size or curvatures of the root canals, proving their flexibility and the advantages of using heat-treated NiTi alloy. The increased flexibility and strength resistance of these files is an advantage for the clinician and recommends their clinical use in comparison with other systems. In addition, studies showed that heat treatments of NiTi instruments during or after the manufacturing process are reducing the internal stress and surface defects due to the grinding process [8], thus preventing their fracture.

When analyzing not only the increase of area, but also the trajectory of the root canals on the final CBCTs comparative to the initial ones, all systems respected the original path of the root canals, but these modifications were not quantified in the present study.

CONCLUSIONS

All systems proved their ability in shaping root canals in a short period of time, with minimal removal of tooth substance and maintenance of the original trajectory of the root canals.

From all the compared systems, TruNatomy proved to be the fastest, while VDW.ROTATE was the most conservative, according to the mean values obtained regarding the time or area analysis.

No instruments were fractured during shaping procedures, proving that all systems are flexible and have an increase fracture strength resistance.

Further studies are necessary using more calibrated root canals, with exactly same dimension, length, curvature angles, and a larger number of samples and instruments have to be considered in order to validate the results of the present study

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Table 1. Minimum, maximum, mean values and standard deviation for the time and area analysis of the four groups

	No	Time			Area i			Area f			Diff Area		
Group		Min	Max	Mean+/-Sd	Min	Max	Mean+/-Sd	Min	Max	Mean+/-Sd	Min	Max	Mean+/-Sd
PTG	6	27.74	99.2	63.003+/-28.430	0.282	0.723	0.466+/-0.174	0.505	0.984	0.722+/-0.190	0.095	0.561	0.256+/-0.146
TRN	6	7.3	31.67	14.053+/-9.408	0.152	0.363	0.275+/-0.074	0.205	0.59	0.412+/-0.116	0.053	0.376	0.137+/-0.108
R25	6	5.95	77.84	53.075+/-27.082	0.201	0.558	0.376+/-0.132	0.363	0.712	0.538+/-0.123	0.119	0.25	0.024+/-0.04
ROT	6	8.18	89.89	39.99+/-31.373	0.402	0.558	0.490+/-0.053	0.441	0.667	0.593+/-0.074	0.024	0.162	0.103+/-0.05
P-value			0.019822474						0.112236987				

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