TOMOGRAPHIC COMPARISON OF VORTEX BLUE AND PROTAPER NEXT CENTER CAPACITY

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ABSTRACT

Background: The permanent improvement of the metallurgical characteristics of the nickel titanium alloy (NiTi) in order to reduce the iatrogenic alterations when curved root canals are instrumented, has been carried out with the application of thermo-mechanical treatments to make instruments more flexible, resistant to cyclic fatigue and with better centering capacity. This study aims to determinethe ability to center the Vortex Blue system compared to Protaper Next in root canals observed with computed tomography, using Proglider to perform pre-enlargement. **Materials and methods:** Quasi-experimental in vitro study with a sample of 30 synthetic teeth with endodontic access cavity previously designed by an expert, which were divided into two experimental groups, the meso-buccal root canals were instrumented with the PTN and VB systems, prior enlargement with PG. Pre and post instrumentation tomographies with standardized position were taken to measure the centricity and transportation in cross sections at 1mm, 3mm and 6mm. **Results**: The highest values were 6mm where the median was 0.444 in PG / PTN and 3mm with a median of 0.333 in PG / VB, for no case was 1. This analysis was complemented with the transportation measures, whose highest values were at 6 mm with a median of 0.080 with PG / PTN and at 3 mm with PG / VB with a median of 0.100, it did not in any case give 0. However, for either measure the result was statistically significant ($p > 0.05$). **Conclusions**: Instruments made with improvements in the NiTi alloy (PTN and VB), a good access cavity and the enlargement allow to perform the instrumentation of the root canals with severe curvatures with greater efficiency, reducing the transport of the root canal of its original position and by the both improving the prognosis of endodontic treatments.

Key words: Centricity, transportation, alloys, endodontics, tomographic analysis.

INTRODUCTION

One of the main goals of contemporary endodontic therapy is to keep the periradicular tissues free of inflammatory and / or infectious processes. To fulfill this purpose, protocols are used that include the removal or debridement of pulp tissue, combining irrigation procedures and instrumentation such as manual and mechanized preparation techniques. During this type of procedure the formation of steps, perforations, canal transportation and decrease the risk of separation of instruments should be avoided.[1]

Historically, endodontic instruments have been made of stainless steel, but because of their rigidity, when used in curved canals (especially when using a diameter greater than 0.20 mm), these instruments tend to cause greater wear on the external wall of the curvature of the root canal compared to the internal wall of the root canal, due to its inability to adapt to the root morphology due to its metallurgical characteristics; Thus causing alteration of the original shape of the root canal, going contrary to the principles described by Schilder in 1967, which propose to maintain the original three-dimensional shape and position of the root canal. This phenomenon causes a reduction of the working length, weakening of the external wall of the root canal (increasing the risk of root fractures), thus

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undermining the prognosis of endodontic treatment.[2-3]

Since the introduction in 1988 of the NiTi alloy in order to produce endodontic instruments for the preparation of root canals, complications have been greatly reduced during the biomechanical preparation, due to the improvement of the alloy in terms of its flexibility and superior strength cyclic and torsional fracture compared to other similar stainless steel instruments.[2]

In 2007 the conventional NiTi alloy was subjected to thermo-mechanical modifications in order to optimize the crystallographic structure of the alloy, giving rise to a new alloy (M-Wire Dentsply Tulsa Dental Specialties), which unlike the instrumentation systems made with the conventional NiTi alloy in the austenitic state, the M wire is produced in a martensitic state, allowing to increase the fatigue resistance of the since they can be easily deformed but recover their shape at temperatures above the transformation temperature.[4.5.8] In 2010, CM Wire DS Dental, Johnson City, TN, produced by Medium of a thermo-mechanical treatments that allows to manufacture extremely flexible instruments in martensitic phase at body temperature. In the instruments manufactured in wire M and CM the austenite transformation temperatures have been increased. [4-6] With the advent of all these improvements in the alloy, and in order to reduce time, simplify endodontic therapy and avoid complications during the procedure, a wide variety of instrumentation systems have been developed for the preparation of root canals, which makes it necessary for professionals to know the characteristics and kinematics of the same for the appropriate selection according to the clinical case to be treated.[2]

The Protaper Next instrumentation system (PTN; Dentsply Maillefer, Ballaigues, Switzerland) is made with M wire and it's instruments are designed in such a way that a continuous wave propagates along the active part of the moving instrument, this allows to diminish the effect of screwing of the instrument inside the canal.[2]

PTN instruments have an off-center rectangular cross-section; While the degree of widening changes according to the instruments: X1 and X2 have a percentage of increase and decrease of conicity, while X3, X4 and X5 have a fixed conicity from D1 - D3 and then have a decrease of their conicity on the rest of their active part.[2]

The Vortex Blue (VB; Tulsa USA Dentsply) system is similarly made with M wire, which is subjected to an innovative thermo-mechanical heating-cooling process in the absence of oxygen, resulting in the formation of a visible oxide layer titanium alloy that allows a control in the transition of temperatures creating a shape memory alloy, characteristic blue color, increasing it's hardness, resistance to wear, flexibility and its ability to center. The System consists of instruments with constant conicity of 0.4 mm or 0.6 mm, ISO 15-50 tip size, convex triangular cross-section, helical angle and variable stretch mark spacing.[1.7.8]

In addition to the improvement of the characteristics of the instrumentation systems, pre-spreading is a procedure that aims to eliminate interferences from the coronal and middle thirds, thus obtaining a straight line access to the foramen, decreasing the contact surface of the And ensuring that the diameter of the root canal is greater than or equal to the size of the tip of the first machined instrument to be used for the biomechanical preparation of the canal, therefore this procedure should be considered the starting point of All biomechanical preparations.[9-11]

Recently, the Proglider instruments (PG; Dentsply Tulsa Dental) were introduced to allow enlargement with a single rotary instrument. PG is made with M wire, has a square cross-section, a semi-active ISO # 16 tip, a changeable degree of widening (0.2 mm - 0.8 mm) and an active surface of 18 mm.[12-13]

At present, the evaluation of the results obtained with the different instrumentation systems can be performed with computed tomography cone-beam (CBCT), among others, which was developed in the late 1990s exclusively for dentistry, with the objective of to obtain images with lower doses of radiation and better resolution, compared with conventional medical tomography. The CBCT produces a true reconstruction of the 3D object with cubic voxels and isotropic resolution, which allows to make cuts that can be recreated in any of the planes, [14-15] therefore allows to observe the geometry of the canal before and after being instrumented. [16.]

The permanent improvement of the metallurgical characteristics of the nickel titanium alloy (NiTi) in order to reduce the iatrogenic alterations when conducting curved ducts has been carried out with the application of thermo-mechanical treatments to make instruments more flexible, resistant to fatigue cyclic and with better centering capacity. The aim of this study was to determine the ability to center the Vortex Blue (VB) system compared to Protaper Next (PTN) in root canals observed with computed tomography, using Proglider (PG) to perform enlargement.

MATERIALS AND METHODS

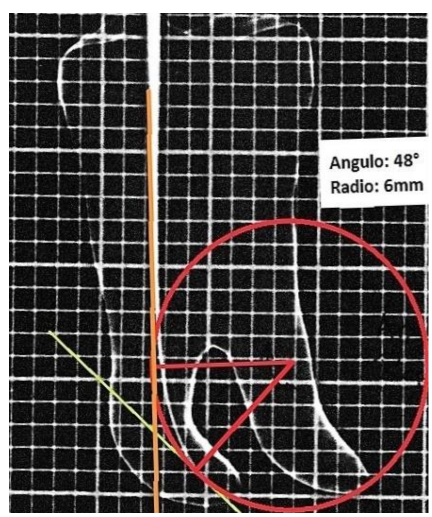
For this investigation a quasi-experimental design was used in vitro, with a sample consisting of 30 synthetic teeth made with an endodontic access cavity previously designed by an expert for the standardization of the sample. The mechanical properties of the material used for tooth processing were as follows: tensile strength (80-100 MPa), hardness (2300-3200 MPa) and modulus of elasticity (2300-3300 MPa).

The curvature (48°) and radius of curvature (6mm) were determined in the meso-buccal canals of the first synthetic lower molars, according to Pruett's parameters (Figure 1), which establish that the shape of a canal is known More accurately by measuring the degree and radius of the curvature, since two canals with the same angle of curvature may have different radius, which directly affects the fatigue of the instrument and the pressure with which the instrumentation of the canal is performed . The working length and permeability of each of the teeth were verified clinically with illumination and 3X magnification magnifiers. The working length was 23 mm (using the meso-buccal cusp as a reference) and was determined by passing a K # 10 file and subtracting 1 mm.

In a pilot test with 4 teeth and 4 operators, the operator calibration was performed using the statistical test of Intraclass Correlation Coefficient and the teeth were randomly divided into two experimental groups (n = 15, each) in Proglider / Protaper Next (PG / PTN) and Proglider / Vortex Blue (PG / VB) respectively, using the program Epidat 3.1. The teeth were mounted in three acrylic blocks with 8 teeth each and a block with 6 teeth; who were then given the pre-instrumentation tomography with a standardized position.

Instrumentation of root canals. Irrigation was done with 5.25% sodium hypochlorite (NaOCl 5.25%), a (VDW Silver Reciproc) electric motor was used. The speed and torque recommended by the manufacturer were used in each of the instruments. The pre-spreading was performed with PG up to the working length using a torque of 200 g / cm and 300 revolutions per minute (rpm). From the sequence of PTN instruments were used: X1 / 0.4 mm and X2 25 / 0.6 mm with 400 g / cm and 300 rpm torque and VB # 15 and # 20 0.6 mm with a torque of 80 g / cm and 500 rpm; # 25 / 0.6 mm with a torque of 100 g / cm and 500 rpm irrigating with NaOCl 5.25% between instruments and making patency with a K # 10 file. Each instrument was used for the preparation of three canals. A final irrigation was done with 3 ml of 5.25% NaOCl to remove residues produced during the instrumentation and afterwards, the tomography was performed after instrumentation with the same standardized position.

Figure 1. Determination of the degree and radius of curvature according to Pruett parameters.



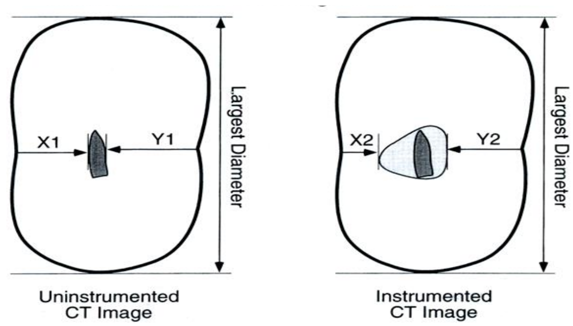
Standardization for tomography. The acrylic blocks were aligned perpendicularly with respect to the cone of the tomograph and were scanned pre and post instrumentation with a standardized position, using a TCRC scanner (Veraviewepocs 3D; J. Morita, Kyoto, Japan) operated at 64 kV and 1 mA. The field of vision was 8 cm in diameter and 8 cm in height. The cuts were 800 x 800 pixels, with a pixel size of 0.125mm.

Image analysis. The pre and post instrumentation measurements of the meso-buccal canals were calculated in cross sections at 1mm, 3mm and 6mm from the apex. The ability of the instrument to remain centered in the root canal was determined by calculating the centricity quotient. This was calculated with the following formula (X1 - X2) / (Y1 - Y2) or (Y1 - Y2) / (X1 - X2), where X1 represents the shortest distance from the contour of the curved root to the periphery of the uninstrumented canal, Y1 represents the shortest distance from the contour of the curved root to the periphery of the uninstrumented canal, X2 represents the shortest distance from the contour of the curved root to the periphery of the instrumented canal and Y2 represents the shortest distance from the contour of the curved root to the periphery of the instrumented canal both mesial and distal. The numerator was the smaller value of the two numbers obtained from the operation of (X1 - X2) and (Y1 - Y2), if these numbers were not equal. A result of 1 for the ratio of the centering capacity would indicate a perfect centering.[17]

The transport of the canal was determined by applying the following formula at the determined distances, (X1 - X2) - (Y1 - Y2); using the same description of the variables to determine the centricity. A result of 0 indicates no canal transportation (Figure 2); [17] the values obtained with these equations must be presented and interpreted as absolute values.

Statistic analysis. The values obtained are expressed in mm. The mean, standard deviation and median were calculated for each group. The Shapiro Wilk test was used to determine the normality of the data, if there was normality (value $p > 0.05$), a Student's t-parametric test was used. If the data were not normal ($p < 0.05$), a non-parametric Mann Whitney U test was used. Level of significance at 0.05.

Figure 2. Measurements for cross-sectional image



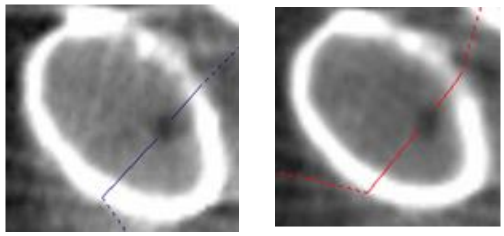
Source: Gambill J. Del Rio C. Comparison of Nickel-Titanium and Stainless Steel Hand-File Instrumentation Using Computed Tomography. JOE. Nineteen ninety six; 22 (7): 369-375

RESULTS

When analyzing the centricity results, values closest to 1 (perfect centering) were presented at 6 mm where the median was 0.444 in PG / PTN and at 3 mm with a median of 0.333 in PG / VB, results that when compared were not statistically significant ($p > 0.05$). (Table 1)

Complementing the analysis of the centricity, the transport of the canal was evaluated, considering that the values closer to 0, indicate that there is not transportation of the canal; thus, the lowest value was obtained at 1mm with median of 0.010 and the highest value at 6mm with a median of 0.080 in the PG / PTN group; In the PG / VB group, the lowest value was obtained at 1mm with a median of 0.020 and the highest value The lowest value was obtained at 1mm with a median of 0.010 and the highest value at 6mm with a median of 0.080 in the PG / PTN group; In the PG / VB group the lowest value was obtained at 1mm with a median of 0.020 and the highest value with a median of 0.100 at 3mm, which also did not represent a statistically significant difference when comparing them (table 1).

Figure 3. Measurements in pre and post instrumentation tomography.



On the left are pre-instrumentation (blue) tomographic measurements. On the right tomographic measurements after instrumentation (red).

TABLE 1. Mean, standard deviation and median of apical transport (1, 3, 6 mm), centering capacity and statistical analysis

Long. mm	**Evaluation**	**PG/PNT**			**PG/VB**			**P value**
		Prom	DE	Med	Prom	DE	Med	
1	Transportation	-0,004	0,733	-0,010	0,221	0,446	0,020	0,187
	Centered	0,206	0,372	0,195	0,334	0,298	0,300	0,309
3	Transportation	0,243	0,698	0,060	0,181	0,345	0,100	0,539
	Centered	0,139	0,857	0,298	0,300	0,242	0,333	0,713
6	Transportation	-0,075	0,264	-0,080	-0,023	0,399	0,080	0,677
	Centered	0,401	0,214	0,444	0,232	0,358	0,070	0,074

* Student's t-test was used for: transport of PTN to 6 mm and centering capacity to 1 mm; transport of VB to 3 and 6 mm and centering capacity at 1mm; transport of VB to 3 and 6 mm and in centering capacity to 1 mm. For all other categories, use U De Mann Whitney test.

DISCUSSION

During the endodontic treatment and specifically in the biomechanical preparation, the instruments must exert a cutting action on the dentinal walls of the canal homogeneously; however, when wear is not proportional to some of the walls, the result will be a change in the original spatial location of the canal, resulting in the creation of steps, canal transportation, perforations, among others,[2] which negatively impacts In the long-term prognosis of the endodontically treated tooth.

The factors inherent to endodontic procedures that could modify the original position of the root canal and thus affect its spatial centricity are: (a) factors inherent to the operator, (b) endodontic access cavity, (c) enlargement of the canals, D) type of alloy of instruments (e) design of instruments, (f) type of movement and (g) degree and radius of curvature (the higher the degree and the lower radius of curvature, the greater the risk of transportation).[6]

The present study compared the centering capacity and transportation of the VB and PTN systems, performing enlargement with PG files and controlling the majority of variables that affect the centricity of the canal, except for the design of the instruments. To perform the measurements of the pre and post instrumentation duct, the TCRC was used; which is a non-invasive diagnostic aid and easily reproducible that allows to compare the shape of the canal before and after instrumentation, in a previously standardized position.[12]

The results of this research show minimum values of decentricity and canal transport in the two groups (100% of the sample) and in the three measurement levels evaluated, which, when comparing the data in the two groups, do not exist statistically differences Significant ($p > 0.05$).

When comparative analysis of the values obtained at different lengths and starting from the premise that an apical transport of more than 0.3 mm negatively affects the prognosis of the endodontic treatment, because a suitable seal is not obtained during the obturation, [12.18] the results of this research coincide with those of Zanesco and col (2017) who, when evaluating the ability to center and transport K files, Reciproc (VDW, Munich, Germany) and the PTN system, using tomography in cross sections at 1 , 4 and 7 mm and determined that the PTN centering capacity was less than 1 mm and with respect to transportation, the value closest to 0 was also present at this same length, [19] which determines that in the third apical is the area where less transportation is generated during biomechanical preparation.

Analyzing the data obtained at 3 mm, the centering values and the canal transportation tend to increase, in agreement with the study by Azunoglu and col (2015) where they also compared tomographically in cross sections at 1, 2, 3, 4 and 5mm the centricity and the transportation of PTN and One Shape (OS, Micro Mega, Besançon, France). [20]

Finally, with the analysis of the more cervical zone (6mm), the data allowed to show that increasing the measurement length also increases the transportation and improves the centering capacity, similar to that reported by Silva and col. (2016) who evaluated the Twisted File Adaptive (SynbronEndo Orange, CA, USA) and compared them with mesial roots of lower molar molars observed with tomography in 3, 5, and 7 mm transverse sections, obtaining values with similar behaviors.[21] The variability of the results could be explained by differences in methodology that was used during each study.

In this study, the results obtained for Vortex Blue showed the same behavior as previously described for PTN. The minimum values of transportation obtained in the apical area and the greater capacity of centering in the more cervical zone are explained by the expected conical shape as a result of the preparation and the design of the instruments with which the pre-spreading and the biomechanical preparation of the canals.

As for enlargement, Elnaghy and col (2014) and Kirhhoff (2015), corroborate that pre-spreading with PG prior to PTN instrumentation results in less canal transportation, compared when instrumented using PTN without enlargement,[12] as this helps to maintain the original shape and position of the canal by eliminating interference from the middle and third coronal, allows a straight line access to the foramen, facilitates irrigation of the entire canal, decreases tension on the instrument, creation of iatrogenic aberrations and ensures that the diameter of the root canal is greater than or equal to the size of the tip of the first rotating instrument used, therefore, should be the starting point of all biomechanical preparations. [9-11]

During this investigation there were no perforations or fractures of instruments, since as mentioned by Berruti and col. (2004) and Patiño and col. (2005) manual or mechanical enlargement is mandatory to reduce the tension on the instrument and therefore, risk of fracture.[22-23] Manufacturers currently recommend pre-flushing at least the size of an instrument # 15.[24]

In addition to enlargement, the M wire has produced benefits with respect to the efficiency and safety of the endodontic instruments, because it allows to optimize the micro structure of the NiTi alloy and to improve the mechanical behavior of the files.[25] On the other hand, Blue thermos-mechanical treatment, improves cutting capacity and centering capacity, increases resistance to cyclic fatigue and decreases the shape memory of files, the latter allows these instruments to maintain the shape given to them, a characteristic that is not observes when evaluating instruments made with conventional NiTi alloy with shape memory, which return to their original straight position after being precurved.[26]

Gao and col. (2012) evaluated the impact of raw materials (stainless steel, conventional NiTi, M wire, and NiTi Vortex Blue) on the fatigue strength of instruments (25 / 0.6 mm) by rotating limes in canals made of steel. The results showed that there were significant differences between the materials with respect to the average life of fatigue and in the flexibility. The NiTi Vortex Blue alloy was located first in the half-life of fatigue and flexibility, followed by M wire, conventional NiTi alloy and, finally, stainless steel.[27]

In general, if the instrument is more flexible, less apical transportation should be present, due to the lower tendency of the instrument to straighten inside the canal, this characteristic depends on the type of alloy, cross section and the diameter of the instrument core.[29]

It is recommended to carry out in vivo studies with a representative sample size, including all variables that can modify the original position of the canal and thus extrapolate the results to the population.

CONCLUSIONS

In the development of endodontic instruments, the improvement of the NiTi alloy allows to increase the efficiency and to reduce the transport of the original position of the canals with severe curvatures and radius of 6 mm in the biomechanical preparation.
The preparation of the canals with the PTN and VB instrumentation systems showed minimal changes in the original position in the apical third, which improves the prognosis of endodontic treatments. Similarly, in the middle and cervical thirds these undesirable effects are reduced with procedures such as improvement in the access cavities and pre-widening of the canals.

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