# COMPARATIVE CONE-BEAM COMPUTED TOMOGRAPHY ASSESSMENT OF ROOT CANAL PREPARATION WITH TWO NICKEL-TITANIUM ROTARY SYSTEMS IN MAXILLARY MOLARS

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***Keywords:*** *CBCT, rotary files, NiTi, root canal preparation*

***Abstract:*** *The objective of our study was to compare and assess the outcome of root canal preparation of maxillary molars with two nickel-titanium (NiTi) rotary systems using CBCT. Ten maxillary molars were selected for this study, randomly divided into 2 groups with respect to the angle of canal curvature and submitted to standardized radiographs and CBCT, before and after instrumentation with ProTaper Next (group 1) and One Shape (group 2). The canals were three-dimensionally reconstructed and evaluated for the following parameters: changes in canal volume, percentage of shaped canal walls and degree of canal transportation. Friedman One way ANOVA at 2mm, 5m and 8mm was used for the statistical analysis. There was no significant difference between the two groups before or after instrumentation. Both rotary systems were efficient and safe in shaping the root canals, without deviation of the original pathway of the canals.*

## INTRODUCTION

The key to a successful and predictive endodontic treatment is represented by a continuously tapered preparation while maintaining the original curvature of the root canal. Various root canal preparation techniques have been developed with changes being made in the materials and designs of the root canal instruments to overcome these problems. Reports from the various studies show that stainless steel instruments lead to a high incidence of transportation and straightening of the canal.(1-5) Since the introduction of nickel-titanium (NiTi) rotary instruments in the 1990s, new rotary files and NiTi systems have been continuously developed to increase instruments efficiency and decrease risk of fracture in files. The effect of instrumentation on root canal morphology has been assessed in a number of studies by using CBCT. The variations in the root and root canal anatomy can be best diagnosed and treated with the help of preoperative radiographs taken at different angulations.(6) The numerous disadvantages of conventional radiography (high dosage required for image acquisition, the inability to modify or store images and the need for chemicals to process the images) have been greatly reduced by digital radiography, but still the main limitation of any radiography is the superimposition of structures, since it produces a two-dimensional view of a three-dimensional object.(7) Cone beam computed tomography (CBCT) scanning is a relatively recent developed diagnostic imaging modality used in endodontics for the effective and qualitative assessment of roots and root canal systems. It uses a cone-shaped beam of radiation to acquire a volume in a single 360-degree rotation, similar to panoramic radiography.

In CBCT, the superimposition of surrounding structures has been greatly reduced or eliminated, and 3D reconstruction of the images is possible.(8)

## PURPOSE

The aim of this *in vitro* study was to compare and assess the root canal preparation outcome with two nickel-titanium (NiTi) rotary systems in curved root canal using Cone Beam Computed Tomography.

## MATERIALS AND METHODS

**Selection of teeth**

After ethics committee approval, 10 extracted human maxillary first molars with fully formed apices were selected and stored in 0.1% thymol until used. Teeth were extracted for reasons not related to this study.

Each molar was cleaned from the debris and soft-tissue remnants on the external root surface and washed in running water and dried off. Each tooth was submitted to standardized radiographs (Vatech Co., LTD-Rep. Coreea) in buccolingual and mesiodistal projections in order to detect any possible root canal obstruction, internal resorption, caries and mesial canals with independent apical foramina and to CBCT scanning, before and after canal preparation. The mesiobuccal 2 root canal was not taken into consideration. The curvature angle was measured using an open source image analysis program (EasyDent V4 Viewer v4.1.5.0, Vatech, Coreea).

Based on radiographs taken prior instrumentation with the initial instrument inserted into the canal (#10 SS K-file), the teeth were randomly divided into 2 groups with respect to the angle of canal curvature. The group 1 included the teeth instrumented with ProTaper Next (Dentsply-Maillefer) and for group 2, instrumentation was performed with One Shape (MicroMega).

Measurement of canal angulation according to the Schneider's method (1971) (9) was performed as follows: point *A* represents the point at the middle of the file at the level of canal orifice. A straight line is drawn aligned parallel to the file image, from point A to a point where the instrument deviated from the line, point *B.* A third point *C* is made at the apical foramina and a line is drawn joining points *B* and *C*. The angle formed by the intersection of lines is recorded as canal curvature.(10) (figure no. 1). Roots with curvatures between 9 and 45 degrees were selected for this study.

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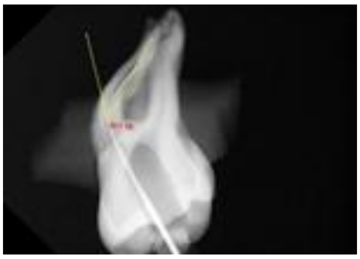
**Figure no. 1. Measurement of root canal angulation (Schneider's method) - the angle formed by the 2 lines intersected represents the canal curvature (42.1 degree – in this case)**



**CBCT Scans**

The molars were oriented so that the long axis of the roots was perpendicular to the CBCT beam before and after preparation (Kodak 9000C 3D Extraoral Imaging System, PracticeWorks Inc, Kodak Dental Systems, Atlanta).

The teeth were embedded in one customized block made from of pink modelling wax in a simulated dental arch. The block of wax was then mounted on the CBCT support in order to capture the images in arch mode. Each molar was placed in the block in such a way that they could be easily removed and positioned back. Thus, after pre-operative scan the teeth were maintained in their respective positions for instrumentation with the respective files and post-operative positioning of the samples was standardized. Area of scan that was established: 5*5 cm at Kv: 90, mA: 8 and mGy cm 2: 610.

After scanning, the CBCT's imaging software (Kodak Dental Imaging Software 3D module v 2.2) produced cross-sectional images starting from 1mm from the apex to the coronary orifice. Starting from 2mm, 5mm and 8 mm – 3 levels were being chosen for the CBCT evaluation.

The scanned images were superposed using the external circumference of the root as a reference for each group and compared using Corel Photo Paint software version X7 2017.

**Root canal instrumentation**

**Group I - Protaper Next** (Dentsply-MailleferBallaigues, Switzerland) (PTN) - after checking the patency of the canal, Endo Z bur (DentsplyMaillefer, Ballaigues, Switzerland) was used to pre-flare the orifice of the root canal. Flaring was followed by irrigation with 5 mL of 5.25% NaOCl delivered in a syringe with a 27-gauge needle (Endo Eze; Ultradent Products Inc, South Jordan, UT). PTN X1 file was used to prepare the shape of the root canal following the glide path, until a full working-length was reached, according to the manufacturer's recommended speed of 300 rpm and torque 200 Gcm, in outward brushing motion. After every few millimetres of file progression, the file was removed to inspect and clean the flutes. The PTN X2 file was used after PTN X1. Patency was again checked with #10 K- file.

**Group 2 - OneShape** (MicroMéga, Bensançon, France) (OS), after the canals were first prepared with NiTi K-files (DentsplyMaillefer) to #15 file, root canal preparation was then performed to the WL with OS rotary file #25.06, according to the manufacturer's recommended speed of 400 rpm and a torque of 160 Gcm. The instrument was moved in the apical direction using an in-and-out pecking motion of about 3mm in amplitude with a light apical pressure. After 3 pecking motions, the instrument was removed from the canal and cleaned.

A single operator with expertise in performing root canal treatment performed all preparations. Each instrument was replaced after preparing 5 canals. The pulp chamber was filled with 5.25% NaOCl (Cloraxid, Cerkamed, StalowaWola, Poland) throughout instrumentation and 2ml 5.25% NaOCl was used to irrigate the canal between each instrument. After instrumentation, we used 5ml 5.25% NaOCl to irrigate the canal for 5 minutes, followed by 5ml 17% EDTA (Meta Biomed MD-Cleanser Solution, South Korea) for 3 minutes. Before entering the root canal each file was coated with 17% EDTA gel (MetaCcom Biomed MD-ChelCream, South Korea).

Post-instrumentation scans were conducted using the same parameters as pre-operative scans to maintain standardization throughout the procedure; afterwards the canals were three-dimensionally reconstructed and evaluated for the following parameters: changes in canal volume, percentage of shaped canal walls and degree of canal transportation.

**Centering ability** indicates the ability of the file to stay centered in the canal.(9) The following formula given by Gambill (3) was used at each level: (A1-A2) / (B1-B2) or (B1-B2) / (A1-A2), where:

- A1 is the shortest distance from the mesial edge of the root to the mesial edge of the un-instrumented canal;
- B1 is the shortest distance from distal edge of the root to the distal edge of the un-instrumented canal
- A2 is the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal
- B2 is the shortest distance from distal edge of the root to the distal edge of the instrumented canal. A result of "1" indicates perfect centering.

**Diameter change** was determined with the following formula: (A1-A2)+(B1-B2)}.

**Canal transportation**, defined as any undesirable deviation from natural canal path, was measured by the distance between the prepared canal center and the anatomic canal center, using the technique developed by Gambill *et al*.(5), as follows:(A1-A2)-(B1-B2).

**Statistical Analysis:**

Quantitative data were summarized as median and interquartile range (Q1-Q3), where Q = quartile (1=first, or $25^{th}$ percentile; 3=third, or $75^{th}$ percentile), due to the size of the sample. Comparisons of baseline (initial) and final characteristic between groups were done with Mann-Whitney Test.

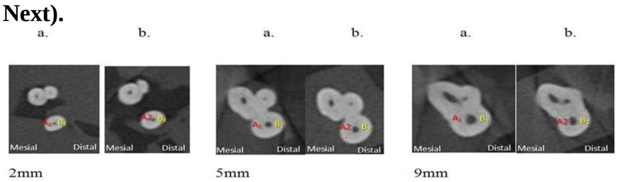
Centering ability, Diameter change and Canal transportation between Protaper Next group and One Shape group were compared using Friedman ANOVA at 2mm, 5mm and 8mm.

Statistical analysis was done with Statistica program (StatSoft, USA) at a significance level of 5%. The significance level was adjusted when more than two groups were compared; the post hoc Friedman ANOVA analysis was done at a significance level of 1.67%.

## RESULTS

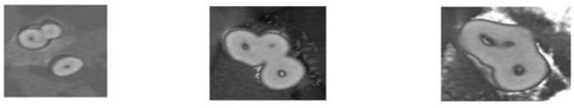
Overall results for the scanning at the selected 3 levels: at 2mm, 5mm and 9mm from the apex, meaning the cross-sectional images at the apical, middle and cervical third of the root canals are shown in figure no. 2.

**Figure no. 2. Scanning at 3 different levels (2mm, 5mm, 9 mm from the apex), preoperative (a.) and postoperative (b.): cross-sectional CT images of maxillary first molar sections showing how transportation and centering ratio were derived (in this case the tooth was prepared with ProTaper Next).**



The images are taken at each selected level before (a.) and after (b.) instrumentation (in this case it was the ProTaper Next system) showing the canal transportation, centering ability and diameter changes. After the superposition of the three-dimensional reconstruction of the images at the apical, middle and cervical third of the root canals, there can be observed a gradual increase in canal size, which was a little more pronounced after instrumentation with the One Shape system (figure no. 3).

**Figure no. 3. Superposition of the scanning images: at 2mm (A), at 5 mm (B) and at 9mm (C).**



A B C

Preoperatively, there were no statistically significant differences between the 2 groups. From the first table it can be observed that there is slight mean increase in every parameter, at the baseline (initial) and final characteristic; there is the *p* value of 0.01. Mean unprepared surfaces varied imperceptibly between individual canals (table no. 1).

**Table no. 1. Baseline and final characteristics of the parameters at the 3 levels of interest, between and amongst the 2 groups**

| | A | B |
|---|---|---|
| 2 mm | | |
| Group 1 | | |
| Baseline | 1.10 (0.85-1.30) | 0.80 (0.55-1.30) |
| Final | 0.70 (0.35-0.85) | 0.70 (0.35-0.85) |
| p-value | 0.0007 | 0.0007 |
| Group 2 | | |
| Baseline | 1.20 (0.95-1.45) | 0.90 (0.75-1.15) |
| Final | 0.90 (0.60-1.20) | 0.70 (0.50-0.95) |
| Stat. (p-value) | 0.0007 | 0.0007 |
| 2 mm Group 1 vs. 2 (Stat. (p-value)) | | |
| Baseline | -0.58 (0.5614) | -0.54 (0.5897) |
| Final | -1.72 (0.0852) | -2.36 (0.0181) |
| 5 mm | | |
| Group 1 | | |
| Baseline | 1.00 (0.90-1.55) | 1.10 (0.80-1.60) |
| Final | 0.90 (0.55-1.30) | 0.70 (0.55-1.25) |
| p-value | 0.0007 | 0.0007 |
| Group 2 | | |
| Baseline | 1.60 (1.15-1.70) | 1.30 (1.05-1.45) |
| Final | 1.20 (0.95-1.30) | 1.00 (0.80-1.15) |
| p-value | 0.0007 | 0.0007 |
| 5 mm Group 1 vs. 2 (Stat. (p-value)) | | |
| Baseline | -1.80 (0.0712) | -0.77 (0.4429) |
| Final | -1.45 (0.1466) | -0.87 (0.3837) |
| 8 mm | | |
| Group 1 | | |
| Baseline | 1.40 (0.90-2.00) | 1.50 (1.10-1.90) |
| Final | 1.10 (0.50-1.65) | 1.10 (0.65-1.55) |
| p-value | 0.0007 | 0.0007 |
| Group 2 | | |
| Baseline | 1.70 (1.20-2.10) | 1.40 (1.30-1.75) |
| Final | 1.30 (1.00-1.65) | 1.20 (1.05-1.55) |
| p-value | 0.0007 | 0.0007 |
| 8 mm Group 1 vs. 2 (Stat. (p-value)) | | |
| Baseline | -0.87 (0.3837) | -0.60 (0.5476) |
| Final | -0.91 (0.3615) | -0.89 (0.3725) |

Instrumentation with PTN and OS led to enlarged canal shapes with no evidence of preparation errors. The two systems maintained the original canal curvature effectively (centering ability), with no significant differences between them. Postoperatively, there was a slight increase in all 3 investigated parameters ($p<.001$). There was no significant difference between the two groups with respect to canal path (canal transportation). At 2 mm level the data reported a highest increase to a diameter change (($p<.001$). Prepared canals were rounder in cross-section and more tapered. There was no significant difference between the two groups (table no. 2).

The results of the instrumentation with the two rotary system files showed visibly error-free shapes of the root canals, with similar amounts of dentine removed, relatively round in cross-sections; there were not any instruments or fragments remained in the root canals.

**Table no. 2. Values of the three parameters: canal transportation, diameter change after intrumentation with the two NiTi rotary files.**

| | Canal Transportation | Diameter Changes | Centering Ability |
|---|---|---|---|
| **2 mm** | | | |
| Group 1 | 0.00 (0.00–0.15) | 0.60 (0.50–1.35) | 1.00 (1.00–1.33) |
| Group 2 | 0.10 (0.00–0.15) | 0.40 (0.35–0.60) | 1.33 (1.00–2.00) |
| Stat. (p-value) | -0.25 (0.8035) | 2.18 (0.0294) | -0.89 (0.3725) |
| **5 mm** | | | |
| Group 1 | 0.00 (-0.10–0.05) | 0.50 (0.40–0.70) | 1.00 (0.67–1.17) |
| Group 2 | 0.00 (0.00–0.10) | 0.60 (0.50–0.70) | 1.00 (1.00–1.33) |
| Stat. (p-value) | -1.22 (0.2211) | -0.62 (0.5338) | -1.02 (0.3095) |
| **8 mm** | | | |
| Group 1 | -0.10 (-0.15–0.10) | 0.70 (0.50–0.90) | 0.67 (0.50–1.38) |
| Group 2 | 0.00 (-0.10–0.20) | 0.50 (0.50–0.80) | 1.00 (0.71–1.75) |
| Stat. (p-value) | -1.27 (0.2058) | 0.50 (0.6187) | -1.35 (0.1776) |
| Friedman ANOVA test | | | |
| Group 1 | 2.93 (0.2316) | 1.79 (0.40798) | 1.48 (0.4765) |
| Group 2 | 1.85 (0.3967) | 5.38 (0.0679) | 2.54 (0.2805) |

## DISCUSSIONS

The present study has evaluated the changes in the anatomy of the root canals of the maxillary molars after they were instrumented with two NiTi rotary systems, using CBCT scanning.

Because it has been demonstrated that sometimes radiological examination is inconclusive, we have decided to make the distribution of the 2 study groups based on radiographs and then based on CBCT.(11)

With the introduction of newer Ni-Ti based file systems over the past two decades, rotary files have gained predominance over hand files. Apart from its superior bio-compatibility and corrosion resistance, the super-elasticity of the Ni-Ti rotary files may allow less lateral force to be exerted against the canal walls, especially in curved canals, reducing the risk of canal aberrations and better maintaining the original shape.(12,13)

One of the systems that was used for the study, One Shape is a single file system, while the other, ProTaper Next is a multi-file system. The single file technique has been introduced into root canal preparation over the past decade, showing a similar capacity for endodontic system instrumentation as conventional Ni-Ti systems.(14) Between the 2 systems there are differences in terms of design: One Shape has a variable 3 cutting-edge at the tip region and 2 cutting-edge at the shaft region and an asymmetric cross-sectional geometry, it is made for use in continuous rotation (15), while the Pro Taper Next, a fifth generation Ni-Ti rotary file system, has three significant design features, including progressive percentage tapers on a single file, M-wire technology, and the off-set design. These files have been claimed to generate an enlarged space for debris hauling and has a progressive and a regressive taper on a single file.(16,17)

Our findings that ProTaper Next showed the lowest canal transportation, less diameter change than One Shape, creating more contoured shapes with respect to the original root canal anatomy are similar to other studies. Previous studies demonstrated that PTN obtains a homogenous increase in canal taper and less invasive preparation.(18) There are studies according to which the design of the instrument affects the shaping ability of NiTi system (19) and others that show the opposite.(20,21)

In fields of dentistry where 3D imaging is necessary, CBCT is considered by some to be the standard of care.(22-27) CBCT is a complementary modality for specific applications rather than a replacement for 2D imaging modalities.

CBCT scanning helps the clinician in the effective diagnosis of endodontic pathology, determination of root- and alveolar-fractures and analysis of resorptive lesions. It also helps in the differential diagnosis of pathosis of non-endodontic origin for effective pre-surgical evaluation of root-end surgery.(28-31)
Baratto-Filho et al observed that the combined usage of an operating microscope with CBCT scanning resulted in an

improved identification of root canals in maxillary first molars.(32) Even if during the past years CBCT has become more popular in endodontics than conventional radiographs, for its major advantage in imaging of three-dimensional details of the endodontic system, due to the high radiation exposure its routine use should be carefully taken into consideration.(33)

## CONCLUSIONS

Within the limitation of this research (in vitro study, limited number of molars), our results concluded that root canal preparation in maxillary molars with ProTaper Next and One Shape was effective and safe, with little canal transportation. The comparison between the two groups did not show a significant difference in the canal transportation of the root canals.

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